Vol. 24 January, 1931 No. 3

QUARTERLY

OF THE

National Fire Protection Association

For Members only, Annual Subscription $3.00.

Entered as second-class matter December 15, 1928, at the Post Office at Boston, Mass., under act of March 3, 1879.

60 BATTERYMARCH STREET, BOSTON, MASS.

National Fire Protection Association

INTERNATIONAL

Executive Office, 60 Batterymarch Street, Boston, Mass., U. S. A.

OFFICERS

F. T. MOSES, PRESIDENT
SUMNER RHOADES, FIRST VICE PRESIDENT
H. L. MINER, SECOND VICE PRESIDENT
A. T. BELL, CHAIRMAN BOARD OF DIRECTORS
FRANKLIN H. WENTWORTH, MANAGING DIRECTOR
PERCY BUGBEE, ASSISTANT MANAGING DIRECTOR
ROBERT S. MOULTON, TECHNICAL SECRETARY

Organization Members

American Institute of Architects.
American Institute of Electrical Engineers.
American Society of Heating and Ventilating Engineers.
American Association of Port Authorities.
American Bureau of Aircraft.
American Concrete Institute.
American Electric Railway Association.
American Gas Association.
American Hotel Association.
American Institute of Steel Construction.
American Marine Insurance Syndicates.
American Oil Burner Association.
American Paint and Varnish Manufacturers' Association.
American Petroleum Institute.
American Spice Trade Association.
American Water Works Association.
Arizona Equitable Rating Office.
Arkansas Fire Prevention Bureau.
Asphalt Shingle and Roofing Institute.
Associated Factory Mutual Fire Insurance Co's., Inspection Department.
Associated Lumber Mutual Fire Insurance Companies.
Associated Metal Lath Manufacturers.
Association of Canadian Fire Marshals.
Association of Edison Illuminating Companies.
Association of Electragists.
Association of the Fire Alarm Industry.
Association of the Fire Underwriters of Baltimore City.
Board of Fire Underwriters of Allegheny County.
Board of Fire Underwriters of the Pacific.
Board of Fire Underwriters of the Territory of Hawaii.
Board of Underwriters of New York, with which is incorporated the National Board of Marine Underwriters.
Boston Board of Fire Underwriters.
British Columbia Insurance Underwriters Association, Fire Branch.
Bureau of Explosives.
Canadian Automatic Sprinkler Association.
Canadian Fire Underwriters' Association.
Canadian Manufacturers' Association.
Cast Iron Pipe Research Association.
Central Traction and Lighting Bureau.
Chemical Fire Extinguishers Association, Inc.
Chicago Board of Underwriters.
Chlorine Institute, Inc.
Clay Products Association.
Compressed Gas Manufacturers' Association.
Cotton Insurance Association.
Eastern Underwriters Association.
Eastern Underwriters Inspection Bureau.
Electrical Porcelain Manufacturers' Association.
Factory Insurance Association.
Factory Mutual Laboratories.
Federation of Mutual Fire Insurance Companies.
General Inspection Bureau.
Grain Insurance Association.
Gypsum Association.
Hollow Metal Association.
Hydraulic Society.
Idaho Surveying and Rating Bureau.
Illinois Fire Prevention Association.
Illinois Inspection Bureau.
Improved Risk Mutuals.
Indiana Inspection Bureau.
Institute of Makers of Explosives.
Insurance Association of Providence.
International Acetylene Association.
International Association of Fire Fighters.
International Association of Municipal Electricians.
International Brotherhood of Electrical Workers.
Iowa Insurance Service Bureau.
Kansas Inspection Bureau.
Kentucky Actuarial Bureau.
Lightning Rod Manufacturers' Association.
Louisiana Rating and Fire Prevention Bureau.
Manufacturing Chemists' Association of the United States.
Michigan Inspection Bureau.
Mississippi State Rating Bureau.
Missouri Inspection Bureau.
Motion Picture Producers and Distributors of America, Inc.
Mountain States Inspection Bureau.
Mutual Fire Inspection Bureau.
Mutual Fire Insurance Association.
Mutual Fire Prevention Bureau.
National Association of Credit Men.
National Association of Dyers and Cleaners.
National Association of Engine and Boat Manufacturers, Inc.
National Association of Flat Rolled Steel Manufacturers.
National Association of Insurance Agents.
National Association of Mutual Insurance Companies.
National Association of Safe Manufacturers.
National Automatic Sprinkler Association.
National Board of Fire Underwriters.
National Convention of Insurance Commissioners.
National Electric Light Association.
National Electrical Manufacturers' Association.
National Electrical Wholesalers' Association.
National Lumber Manufacturers' Association.
National Petroleum Association.
Nebraska Inspection Bureau.
New Brunswick Board of Fire Underwriters.
New England Insurance Exchange.
Newfoundland Board of Fire Underwriters.
New Hampshire Board of Underwriters.
New Jersey Schedule Rating Office.
New York Board of Fire Underwriters.
New York Fire Insurance Rating Organization.
Nova Scotia Board of Fire Underwriters.
Ohio Inspection Bureau.
Oil Insurance Association.
Oklahoma Inspection Bureau.
Oregon Insurance Rating Bureau.
Pacific Coast Association of Fire Chiefs.
Philadelphia Fire Underwriters' Association.
Philadelphia Suburban Underwriters' Association.
Portland Cement Association.
Pulverized Fuel Equipment Association.
Pyroxylin Plastics Manufacturers' Association.
Railroad Insurance Association.
Railway Fire Protection Association.
Society of Grain Elevator Superintendents of North America.
Society of Motion Picture Engineers.
South-Eastern Underwriters' Association.
St. Louis Fire Prevention Bureau.
Tennessee Inspection Bureau.
Terminal Elevator Grain Merchants' Association.
Texas Inspection Bureau.
Texas State Fire Insurance Department.
Underwriters' Association of the District of Columbia.
Underwriters' Association of the Middle Department.
Underwriters' Laboratories.
Underwriters' Service Association.
Virginia Insurance Rating Bureau.
Washington Surveying and Rating Bureau.
Western Actuarial Bureau (Fire).
Western Canada Insurance Underwriters' Association.
Western Factory Insurance Association.
Western Sprinkled Risk Association.
Western Underwriters Association.
West Virginia Fire Underwriters' Association.
West Virginia Inspection Bureau.
Wisconsin Inspection Bureau.

Over 4,600 Associate Members.

Printed in U. S. A.

Table of Contents.

EMPIRE STATE BUILDING ..... FRONTISPIECE

EDITORIALS 239

MEASURING FIRE PROTECTION BENEFITS IN DOLLARS. *Clyde M. Wood* 245

THE 1930 U. S. FIRE LOSS 247

PROVIDENCE INSPECTS ITS HOMES 251

UNPROTECTED STEAM PIPE STARTS FIRE 254

THE MUNICIPAL REGULATION OF OIL STORAGE. *Robert S. Moulton* 255

FIRE EFFECTS ON FIRE-RESISTIVE CONSTRUCTION. *Frank Burton* 277

FIREMEN'S SHORT EXTENSION COURSES. *Clarence Goldsmith* 286

PRIVATE FIRE BRIGADE ORGANIZATION, PITTSBURGH PLATE GLASS CO. *J. S. Dodge and H. J. Hartmann* 296

NORWEGIAN ROYAL RESIDENCE FIRE. *Norsk Brandvern Forening* 302

A REVIEW OF SOME RECENT DUST EXPLOSIONS. *David J. Price and Hylton R. Brown* 305

EXPLOSION IN WESTERN MARYLAND RAILWAY COMPANY ELEVATOR, BALTIMORE 307

EXPLOSION AT HOGAN MILL FEED COMPANY PLANT, KANSAS CITY, MISSOURI 313

EXPLOSION AT E. F. CARLSTON ELEVATOR COMPANY, MINNEAPOLIS 318

EXPLOSION AT TOBACCO BY-PRODUCTS AND CHEMICAL CORP. PLANT, RICHMOND 320

EXPLOSION AT STALEY MANUFACTURING COMPANY, DECATUR, ILL. 323

TWO FIRES IN BUILDINGS UNDER CONSTRUCTION 330

STATE EDUCATION BUILDING, HARRISBURG, PA. 330

EMPIRE STATE BUILDING, NEW YORK CITY 333

BROOKLYN OIL REFINERY FIRE 334

CYPREMORT, LOUISIANA, SUGAR HOUSE FIRE. *H. L. McLean* 336

AUTOMOBILE FIRE HAZARDS 338

FIRE RECORD OF AUTOMOBILES 342

LOSS OF LIFE IN AUTOMOBILE FIRES 349

MOTOR BUS FIRES 352

PREVENTION AND EXTINGUISHMENT OF AUTOMOBILE FIRES 356

FIRES IN WHICH THERE WAS LOSS OF LIFE 358

Reports of fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.

The Empire State Building, New York City's most modern skyscraper. Provision had been made for fire protection during construction, and when, despite all precautions, fire started on the forty-seventh floor, the fire pump was started and the fire controlled with a loss of $5000, a small item in comparison with the value of the structure. **(See report on page 333.)**

The Quarterly

Vol. 24 January, 1931 No. 3

The State Fire Marshal. The state fire marshal's office in the United States is in evolution. It would long since have come to a more influential and useful estate were it not so commonly utilized as a political football. In the majority of the states the fire insurance companies are taxed a percentage of their premiums to support the office, and the funds so derived are mostly spent for something else. The French physiocrats would have called this "crooked taxation." One can hardly think of a more fitting name for it. If the state is especially to tax those citizens who are provident enough to insure their property against fire, it should be considered but mere decency to expend that tax to improve the fire safety of the state and thus eventually reduce the cost of insurance. It is politically dishonest to lay a tax for a specific purpose and then use the proceeds to relieve other sources of taxation. The plundering of this state fire marshal fund for the support of other projects has become so habitual that the fire marshals are frequently forced to beg for the allowances for educational purposes that should obviously be at their disposal. Some of them will not do this; they shrug their shoulders, let the educational programs slide, and confine their activities to chasing firebugs. Previous to the organized campaign for the passage of the model arson law, now enacted in twenty-seven states, even their arson prosecutions were largely futile. The fire marshal's office should be financed out of the general funds of the state. Taxing fire insurance premiums for its support leads the unthoughtful common citizen to believe that the office is conducted for the benefit of the insurance companies, and when he sits on a jury in a case of incendiarism, where collection of fire insurance is the alleged motive, this wrong notion makes him reluctant to convict.

Despite the unsatisfactory present status and tenure of the fire marshal's office, demonstrations of effectiveness are here and there recorded. The fire marshal's office of Ontario, in the incumbency of which Mr. Heaton and Mr. Lewis have been undisturbed since its original establishment, has won a commanding place in the polity of the Province, where its educational activities are notably appreciated. The value of the stability of tenure granted these officials is obvious. Their enlightened policies have been given opportunity to register and mature. In North Carolina a most valuable service has been

maintained for a number of years in the education of the fire departments of the state by Sherwood Brockwell, former fire chief of Raleigh and now employed regularly by the fire marshal's office to stimulate and encourage the fire departments to train their men in modern methods of fire attack. What service could possibly be more logical or more useful for every state fire marshal to render?

Fire Marshal Lane of Michigan carried out during last Fire Prevention Week an educational program unique in conception and execution. Twenty-two men with automobiles were appointed special deputies for the period. Each man spent three or four days in an assigned territory, every town in Michigan being visited. Posters, home inspection blanks, the Governor's proclamation, and press matter were distributed effectively. The Michigan Inspection Bureau aided this effort, as it does all good fire prevention projects.

Such special enterprises, and the increasing activity of many other fire marshal offices in distributing educational literature periodically or continuously, suggests the evolution now in process. It was to further this evolution that the Fire Marshal's Section of the N.F.P.A. was created in 1927. In the meetings of this section, and the clearing house for constant exchange of information established by its officers at the headquarters of the N.F.P.A., the fire marshals are enabled to add the collective weight of their influence to the establishment of this office on more stable foundations. Larger opportunities and more secure tenure of office will follow the awakening of the people to the value and significance of the fire marshal's educational work. This state office will then be appreciated for its own sake, for the opportunities of high service it affords, and it will not be sought, as it now sometimes is, as a mere lunch station on the way to more coveted political preferment.

* * * * *

Fire Chiefs to the Rescue. Anybody who doubts that the American people are becoming fire-conscious should have his doubts resolved by listening to the tales of our fire chiefs concerning the multiplicity of devices inventors and salesmen are increasingly calling upon them to endorse. To the Executive Office of the N.F.P.A. also come streams of people, promoters, idealists, cranks and fakers with every imaginable kind of fire alarm, fire retardant or fire extinguishing implement,—one of them once in a while representing a reasonable idea. That there is a constant sale of this worthless trash to inexperienced people seeking fire protection there is not a shadow of a doubt. Salesmen and agents themselves are often deceived by specious and inconsequent tests into making such extravagant claims for their devices as to render their selling campaigns essentially fraudulent.

It is not an easy matter to protect innocent people from such racketeering. It is not like the sale of "dope." The devices are not in themselves

harmful: they are merely worthless. In purchasing them the buyers are simply illustrating Mr. P. T. Barnum's celebrated estimate of American intelligence. But only those should be fooled who are willing to be fooled. Purchasers of fire extinguishers are not without a resource of intelligent opinion. This resource is suggested by an editorial in the *Weekly Underwriter* of November 1st, which says:

> There is a real service that insurance agents can perform by helping their assureds to avoid the purchase of fire extinguishers that will prove inadequate or entirely useless in the moment of need. The public should be encouraged by agents to solicit the advice of fire department men on the effectiveness of any make or type of extinguisher before expending money on it.

That there is no doubt of the fire chiefs' willingness to serve in this fashion; in fact, that they are eager to meet their logical responsibilities in preserving their people from errors of judgment in seeking fire protection, is admirably demonstrated by the current bulletin of the International Association of Fire Chiefs in which appears a signed article by the Association's President, Fire Chief Joseph N. Sullivan of Utica, N. Y. Chief Sullivan says:

> The fire chief should be an adviser of his people in all matters of fire safety. There is great need for his counsel in the protection of the home. Business and industry are now pretty well trained in self-protection. The home, however, is just awakening. It needs the guidance of the fire chief, the man provided by the city for that purpose. The educational value of presidential proclamations, fire prevention week exercises, and the teaching of fire prevention in our schools is stimulating our people to take steps to safeguard their homes, and here is where they need the fire chief's advice. He alone can protect them from the purchase of inadequate fire fighting devices.
>
> It is easy for people to be imposed upon in an unfamiliar field. The lightning-rod salesman was once the black beast of comic literature, the archtype of faker, and yet lightning rods if properly made and installed have always afforded very real protection. The people could not tell the difference between a real and a fake lightning-rod in those days; and in these days they need equal guidance in the purchase of fire extinguishers.
>
> Many extinguishers are effective on certain kinds of fires only. Some will put out fires in oils and grease; some will not. The condition of the extinguisher and the amount of the extinguishing fluid are factors; also the method of applying or projecting the fluid. In this field it is easy for an inexperienced person to be deceived by a false sense of security. If a man desires to have something really effective to use in protecting his family from possible suffocation or fire death, he will stand a better chance of success *if he consults his fire chief* before investing his money in these devices.

The educational program recently inaugurated by the Fire Chiefs' organization is very significant. It means an eventual professional status for fire department officers, and the recognition of that status by the cities in

higher salaries and greater authority and influence. Chief Sullivan is an admirable representative of the progressive element in his Association. His present call to his fellow chiefs follows his own action in stopping the installation of certain types of fire extinguishers in Utica.

* * * * *

Development of a Motive. The article in this issue by our member, Clyde M. Wood of Cleveland, presents an aspect of the fire loss that grows more significant as our industrial organizations grow more interdependent. Suspension of production of a single article of key importance in manufacture may interrupt a chain of deliveries extending through several industrial organizations, thus proving an embarrassment to many more concerns than the one having the fire. Mr. Wood sticks closely to his subject in demonstrating the value of "use and occupancy" insurance to the manufacturer. He is not in the fire insurance business, but the gentlemen making insurance their vocation might well be pleased at his convincing presentation of their case. The ultimate intent of Mr. Wood's article is to advance the cause of fire protection.

"Use and Occupancy" insurance is the handmaiden of the protected plant. To secure this form of indemnity at any reasonable rate of premium the manufacturer must equip his premises with such private fire protection as will make interruption of production by fire most unlikely. A desirable form of insurance of an increasingly significant and necessary sort is thus displayed by Mr. Wood for the contemplation of business prudence, so that its own financial interest may operate as a motive for reducing the fire waste.

Mr. Wood's idea that in protection of their loans the banks may come to require insurance upon continuity of business operation, which is obviously their major concern, is of very considerable significance.

May not the local fire insurance agent also see in this an opportunity to serve the cause of fire prevention without reducing his premium income? Many agents do not encourage automatic fire protection because the installation of sprinklers reduces the insurance rate upon which their income is based. If their loss in revenue through the improvement in risks can be made up through policies of "use and occupancy" insurance, their business will not be adversely affected by the improved fire safety which they are now sometimes accused of impeding.

* * * * *

Credit Information for Fire Departments. No business of today of much importance attempts to operate without accurate credit information. The problem of credit is at no time of greater moment than during periods of financial stringency and business depression. Likewise during hard times the fire department is more fearful of a wave of incendiary fires from the hard-pressed concerns that are willing to "sell out to the insurance companies."

During the past decade we have seen the rapid development of fire prevention bureaus in the fire departments of many of the important cities. The value of organized inspection work in reducing hazards and losses is widely recognized.

We wonder if it may not some day appear a logical refinement in the work of these bureaus that credit information secured from the usual sources be utilized by our fire departments to restrain the incendiary? It would not be a difficult matter for the chief of the bureau to analyze credit information and to provide closer supervision over places that seem liable to burn.

Some cities have already utilized this idea. In Dallas, Texas, for instance, a captain in the fire department was assigned to work with the fire prevention committee of the Chamber of Commerce. The Chamber has a credit bureau for the benefit of its members. The captain studies the credit information available through the bureau and makes a point of inspecting frequently business houses showing an unsatisfactory financial condition.

The familiar presence of a uniformed fire official is a strong deterrent to the shady or desperate business man contemplating arson. Such inspection also takes care of the "unconscious incendiary," the man who gets careless about housekeeping and permits hazards to exist when business is bad. The condition of his premises is noted and corrections ordered.

Credit information is used by business organizations generally. Why should not the fire department, conducting the important public business of fire prevention and extinguishment, likewise utilize credit information? It appears that intelligent use of such information by fire departments may be an important factor in reducing municipal fire losses.

* * * * *

Newspaper Fire Stories. A Brooklyn, N. Y., fire, originally reported in the newspapers as a $1,000,000 conflagration, involved an actual loss of not over $20,000, according to the report published in this issue of the QUARTERLY. The newspaper reports on this fire confused petroleum and turpentine, tanks and stills, and in general gave an inaccurate and confused picture of the fire. This is an example of the traditional inaccuracy of newspaper fire stories. Such inaccuracies are primarily chargeable to the writer's lack of familiarity with the subject. In technical matters the newspaper reporter is frequently unable to obtain correct information, but in stories on ordinary fires the newspaper reports are showing a gradually increasing comprehension of the fundamentals of fire prevention and fire protection. A few years ago a headline "Carelessly Discarded Cigarettes Start Three Fires" was sufficiently unusual to excite much favorable comment from the fire protection fraternity. Intelligent newspaper treatment of fire reports is now becoming more common. A recent headline reading "10 Burn to

Death in Blazing Hotel: Escape Down Single Stairway Is Cut Off," shows a real understanding of a fundamental of fire safety.

Despite all the educational efforts of the fire protection fraternity, newspaper reports of fires continue to be the principal medium through which the public obtains its knowledge of fires and fire prevention. Improvement in the character of these reports is an important factor in public education. N.F.P.A. members can be of material assistance in this direction by making contact with their local editors and taking the time to give full information to reporters whenever they are asked questions.

TRUCKS

By Lori Petri.

A thousand tongues have told of ships,
That ride like swans from strand to strand;
And talked of trains, whose winding trips
Weave serpent tracks in every land.

And men have marked the feline grace
And purring poise of motor cars;
Or sung of darting planes that race
Like dragon flies, toward sun and stars.

But who has praised the massive might
Of those great trucks that bear their loads,
In crates and cases, day and night,
Upon the world's paved, public roads?

Their rumbling bodies, hugely square,
Cylindrical or oblong, gleam
Like monsters throbbingly aware
Of some stupendous, sturdy dream.

On clanking wheels, on velvet tires,
They roll along from mart to mart,
Transporting fuel to feed the fires
Of science and beauty, war and art.

All other carriers give joy
And labor both, to prove their worth;
Trucks have one aim, without alloy—
To serve the hungry needs of earth.

Measuring Fire Protection Benefits in Dollars.

By Clyde M. Wood,
(Member N.F.P.A.).

The measurable dollar value of fire protection to a business can be calculated only by measuring the insurance savings on both property replacement and earning replacement insurance.

This is in line with two thoughts of considerable significance expressed by speakers at the Fire Prevention Session of the National Safety Council at Pittsburgh last September. One speaker familiar with public educational matters stated that the most effective way to interest Business in fire prevention and protection is to demonstrate that financial benefits may be derived therefrom.

How could it be otherwise? The fact that a business firm ceases to exist when it ceases to earn money is an unanswerable reason why every dollar expended should come back, whether the money is spent for fire protection or for something else. There is a better method of inducing merchants and manufacturers to protect their business against fire than the old one of appealing to them as good citizens with quotations of fire waste statistics, or pointing out the wisdom of protecting only their physical property. This is to present the matter from the angle of protection of their earnings.

The companion thought was expressed by Mr. Ralph E. Richman, Editor of *Fire Protection,* when he stated that an effective appeal to Business resides in the idea that proper fire protection preserves the continuity of the business operation, or the "money making process." This is a most timely observation, considering the present day mass production in both manufacturing and merchandising, and the modern contracts for reliable deliveries of products.

Ordinary fire protection provided to protect physical property may not protect the business operation. But complete, modern, automatic fire protection which is designed to protect the manufacturing or merchandising operation must obviously protect also the physical property. Insurance records abound with instances where fire damaged an insignificant few hundred dollars worth of property, but stopped the operation of the business with a resultant *interruption* loss of many thousands of dollars.

An excellent aspect of the two ideas expressed by the Pittsburgh speakers is that there is available a thoroughly practical way of putting them into effect. Nearly all of the advantages of a fire protection investment can actually be measured in dollars by computing the difference in the amount of the fire insurance premium on a plant with and without individual fire protection equipment.

Complete, modern automatic fire protection equipment, together with complete, modern fire insurance, will render a business just about 100% safe against fire loss of its earnings as well as its physical property. Complete, modern fire insurance includes not only insurance on property, but also insurance against discontinuance of earnings as the result of fire. The insurance of earnings is commonly called Use and Occupancy, or Business Interruption Insurance. To arrive at a correct conclusion it is therefore necessary for Business to compare the cost of installing and maintaining complete fire protection with the premium savings which the fire protection equipment effects on fire insurance of earnings as well as on fire insurance of property.

Our tremendous fire losses are largely due to the fact that many business men fail to realize that fire protection will pay. They have never calculated some of the most important money returns effected by fire protection. The one proper method is to figure fire insurance savings effected by complete fire protection on earnings which are discontinued by fire as well as on replaceable property values. Instead many figure the savings on replaceable property values only, and there are still some who do not carry full property fire insurance and who figure the savings on this partial insurance against complete fire protection.

Since a business is operated solely for profit, the buildings, machinery and stock being merely the profit-making tools, and since the burning of the tools also burns the profits, is there any sound reason why earnings should not be insured?

In discovering the causes for non-insurance of earnings, perhaps the most obvious one is that Use and Occupancy or Business Interruption Insurance has become generally known only during the past fifteen years. Of greater significance is the fact that bankers are just beginning to require Use and Occupancy Insurance policies as collateral for loans.

This requirement will almost certainly become general as bankers come to a full appreciation of the value of the protection to their loans which is afforded by fire insurance on earnings out of which loans are repaid. Fundamentally, bankers make loans not on property, but on the ability of the property owners to earn money. The banker expects the loans and interest to be repaid out of earnings, since foreclosure on physical property is most undesirable. For this reason should not the banker require as collateral fire insurance on the earnings as well as on the property through which the earnings are derived? There are many devastators of earnings, such as competition, style changes, etc., which cannot always be forestalled, but the loss of earnings by fire can always be prevented by the simple act of requiring Use and Occupancy Insurance.

The effect of the installation of complete modern fire protection equipment and the complete coverage of earnings and property by fire insurance

will benefit all concerned, and work a hardship on no one, for much more of the present fire waste will be salvaged for Business than will be spent for protection. The bankers' loans will be infinitely more stable, and business earnings will be stabilized and increased.

Perhaps the happiest feature of the ideas expressed by the two speakers at Pittsburgh is the appeal made to Business by the thought of the money made or saved through fire protection that might easily be, and frequently is, lost through the lack of it. The money made, however, is incorrectly computed unless the business man adds to savings in cost of property insurance the savings in cost of "earnings insurance," and this whether or not he carries one or both.

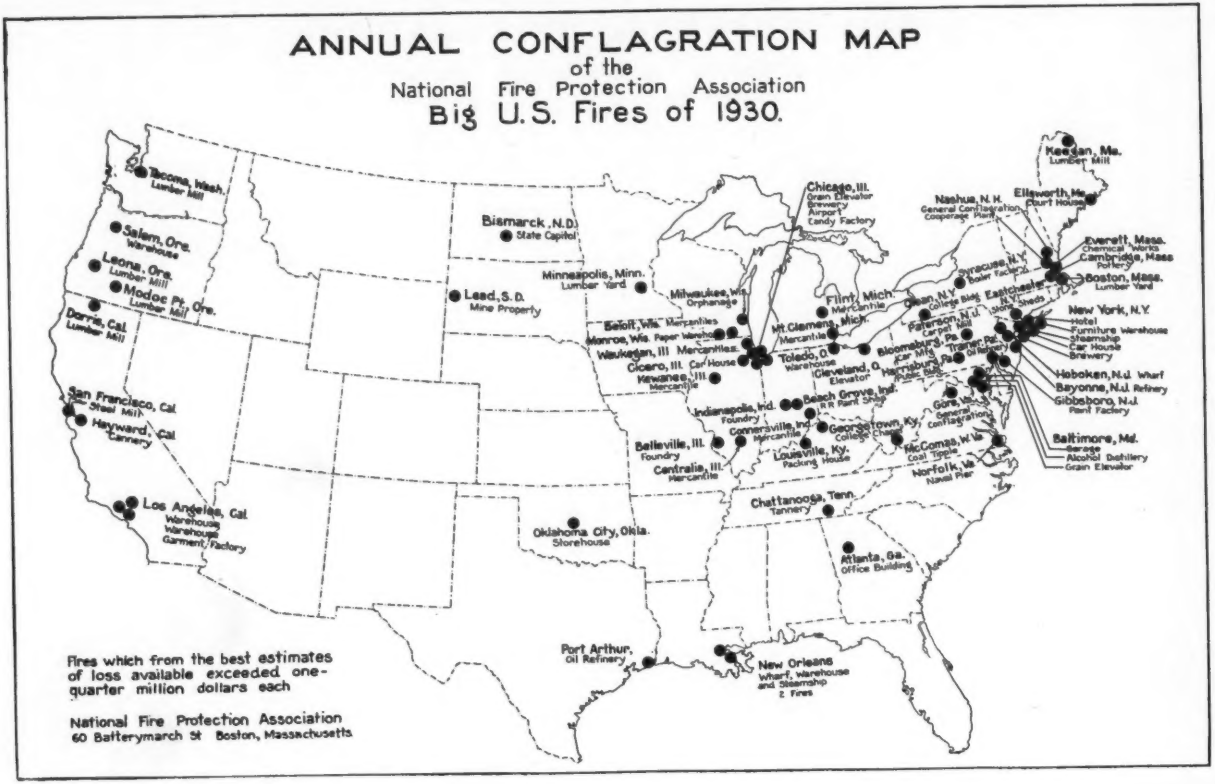
The 1930 U. S. Fire Loss.

The total estimated fire loss in the United States for the year 1930 is $465,000,000. This amount is based on figures compiled by the National Board of Fire Underwriters for the eleven months ended November 30, 1930, with an estimate for December based upon loss experiences for the same month in previous years adjusted for the trend of losses for the current year. The total estimate exceeds the loss for the year 1929 by approximately 45 million dollars (a little more than 10%), and is about the same as the 1928 loss.

From an economic standpoint the year 1930 has been the worst since the depression of 1920-21. General business has retrenched, purchasing power has diminished and the employment problem has become critical. Added to this have been the unusually dry weather conditions which have prevailed over wide areas. These factors have been reflected in the monthly fire waste curve, which from the middle of the summer has shown a distinct upward trend.

At the same time there has been a very considerable decline in commodity prices and merchandise values. It would seem reasonable, therefore, to assume that this would be reflected by a corresponding decrease in fire losses, for more units of any given commodity must be destroyed to cause an equal money loss. This has not been the case and the rise in fire losses in the face of a general price decline seems evidence of an increase even greater than that indicated by the figures.

The direct effects of the drouth on the national fire waste are difficult to determine definitely. An analysis of losses by the National Board of Fire Underwriters, however, indicates that the increase for 1930 has been fairly equally distributed geographically, but that the losses for farm dwellings and buildings have increased notably out of proportion. The reason for this would appear to be the effects of the drouth both from a physical and economic standpoint.


ANNUAL CONFLAGRATION MAP
of the
National Fire Protection Association
Big U.S. Fires of 1930.
Tacoma, Wash. Lumber Mill
Salem, Ore. Warehouse
Leona, Ore. Lumber Mill
Modoc Pt., Ore. Lumber Mill
Darrie, Cal. Lumber Mill
San Francisco, Cal. Steel Mill
Hayward, Cal. Cannery
Los Angeles, Cal. Warehouse Warehouse Garment Factory
Bismarck, N.D. State Capitol
Lead, S.D. Mine Property
Minneapolis, Minn. Lumber Yard
Oklahoma City, Okla. Storehouse
Port Arthur, Oil Refinery
New Orleans Wharf, Warehouse and Steamship 2 Fires
Chicago, Ill. Grain Elevator Brewery Airport Candy Factory
Milwaukee, Wis. Orphanage
Beloit, Wis. Mercantiles
Monroe, Wis. Paper Warehouse
Waukegan, Ill. Mercantiles
Cicero, Ill. Car House
Kewanee, Ill. Mercantile
Belleville, Ill. Foundry
Centralia, Ill. Mercantile
Indianapolis, Ind. Foundry
Connersville, Ind. Mercantile
Beech Grove, Ind. R.R. Paint Shop
Louisville, Ky. Packing House
Georgetown, Ky. College Chapel
Chattanooga, Tenn. Tannery
Atlanta, Ga. Office Building
Flint, Mich. Mercantile
Mt. Clemens, Mich. Mercantile
Toledo, O. Warehouse
Cleveland, O. Elevator
Nashua, N.H. General Conflagration Cooperage Plant
Syracuse, N.Y. Boiler Factory
Paterson, N.J. Carpet Mill
Bloomsburg, Pa. Car Mfg.
Harrisburg, Pa. Public Bldg.
Trenton, N.J. Oil Refinery
Gore, Va. General Conflagration
McComas, W.Va. Coal Tipple
Norfolk, Va. Naval Pier
Keegan, Me. Lumber Mill
Ellsworth, Me. Court House
Everett, Mass. Chemical Works
Cambridge, Mass. Pottery
Boston, Mass. Lumber Yard
Eastchester, N.Y. Seeds
New York, N.Y. Hotel Furniture Warehouse Steamship Car House Brewery
Hoboken, N.J. Wharf
Bayonne, N.J. Refinery
Gibbsboro, N.J. Paint Factory
Baltimore, Md. Garage Alcohol Distillery Grain Elevator
Fires which from the best estimates of loss available exceeded one-quarter million dollars each
National Fire Protection Association
60 Batterymarch St Boston, Massachusetts

Comparative Monthly Losses, 1929 and 1930.

The wave of excessive fire losses started in August, 1930, when the business depression became pronounced, and has continued throughout the year, as may be seen by the following table.

	1929	1930
January	$44,713,825	$42,847,000
February	41,520,290	43,206,940
March	41,277,814	42,964,392
April	36,845,795	43,550,996
May	32,129,408	38,415,142
June	33,605,663	31,818,266
July	31,985,493	34,847,750
August	30,446,893	36,043,679
September	29,249,355	35,230,456
October	31,652,385	36,838,614
November	29,061,869	35,682,577
Total 11 months	$382,488,790	$420,942,812
December	39,726,338	45,000,000 (Est.)
Total 12 months	$422,215,128	$465,942,812 (Est.)

Aggregate Loss for Fifteen Years Approaches Seven Billion Dollars.

The 1930 fire loss brings the total fire waste of the United States during the past fifteen years up to the stupendous sum of $6,703,698,799, an annual average of more than 446 million dollars. Those losses, however, should be considered in relation to present-day burning ratios, which in turn are based upon steadily increasing property values exposed to fire. For example, the fire loss of $258,377,952 in 1916 may very possibly have resulted in as high a burning ratio to the aggregate value of all property in that year as the $465,000,000 loss of 1930 is to present valuations. The following table gives the annual fire loss record by years since 1916.

Annual Fire Losses in the United States from 1916 to 1930 Inclusive.

1916	$258,377,952	1924	$549,062,124
1917	289,535,050	1925	559,418,184
1918	353,878,876	1926	561,980,751
1919	320,540,399	1927	472,933,969
1920	447,886,677	1928	464,607,102
1921	495,406,012	1929	422,215,128
1922	506,541,001	1930 (Est.)	465,942,812
1923	535,372,782	Total	$6,703,698,799

Large Loss Fires in 1930.

The Nashua, N. H., fire of May 4, 1930, destroying more than three hundred buildings (200 of them dwellings), rendering 322 families homeless and causing a property loss of over $2,000,000, was the only major conflagration of the year. During the twelve-month period there were listed but five

fires involving a loss of one million dollars or over as compared with fifteen fires the preceding year and twenty in 1928.

Instead of listing the largest fires of the year as has been customary in years past, they have been spotted on the accompanying map. Only fires involving losses of $250,000 or over have been so spotted. The amount of the loss in such large fires is often difficult to determine accurately, and final figures are in many cases not available in time to include in a record published immediately after the close of the year. It has been necessary therefore to rely on the best available estimates in selecting the fires classified as over $250,000. It is recognized that this may have resulted in including on the map some fires that will subsequently prove to involve a loss of less than the specified figure, but it is believed that the map is substantially correct in the general picture presented of the distribution of large loss fires.

It is difficult to generalize about these large fires, but the greatest number have been in miscellaneous manufacturing property. Property at rail and water terminals, which as a whole is notoriously poorly protected against fire, has contributed many of these large losses. Lumber mills, also generally poorly protected and hazardous due to their large storage of combustible products, have been generous contributors to the list of large loss fires.

The number of fires of the general conflagration type have been notably few. Nashua's conflagration of May 4, already mentioned, was the outstanding one. Group fires on August 5 at Gore, Virginia, and on November 16 at Waukegan, Ill., also might be included in the class of general conflagrations.

In general the geographical distribution follows the concentrations of burnable values as they are generally regarded, but it is interesting to note the considerable number which occurred at points where the property was situated beyond the limits of a municipal water supply or organized fire department.

All of these are fires which need never have occurred. There is no excuse for fires of this magnitude when the fundamental principles of fire prevention and protection have been observed.

Providence Inspects Its Homes.

The unusual campaign conceived and carried out in Providence, Rhode Island, in the fall of 1930, described briefly in this article, should serve as an inspiring example to cities large and small. It is hard to imagine a better planned or better executed fire prevention activity than the successful inspection of every dwelling house in the city.

During the fall of 1929 the plan of dwelling house inspections conducted by Chief Daniel B. Tierney of Arlington, Mass., reported in the October, 1929, QUARTERLY, attracted the attention of Chief Frank Charlesworth of Providence. On December 9, 1929, a meeting of the Fire Prevention Committee of the Providence Safety Council was called, at which meeting Chief Charlesworth had his friend, Chief Tierney, describe the work that had been carried on in Arlington. The committee were enthusiastic over the possibilities of this work, because in Providence, as in nearly every other city, a large proportion of the fires annually occur in dwelling houses. Therefore when Chief Charlesworth stated that he had decided to undertake such a campaign in Providence he was assured of the active support and coöperation of the committee.

The difficulties of carrying out a program of this scope were readily recognized and it was decided at subsequent meetings that the attempt should not be made until all preparations were carefully developed.

As a first step a small card was printed with the wording "We are working with the Providence Fire Department to fight for fewer fires." A large supply of the folder issued by the N.F.P.A., entitled "Keep Your Home from Burning," was also secured. The card and the folder were to be distributed to the house owner by the firemen making the inspections.

The Providence newspapers were then approached and their active cooperation in the campaign secured. It was finally decided to set the date for the opening of the campaign on September 29, 1930, just prior to Fire Prevention Week.

Chief Charlesworth, realizing the very great value in proper public relations for the Fire Department, spared no pains to organize the work properly. The Chief visited every fire station in the city, called all the men together and demonstrated to them the procedure which they were to follow. The men were asked to volunteer for this work on their off-day time and responded to a man to the appeal of the Chief. The men were assigned to work in pairs, and 150 men a day were available for the inspection throughout the campaign.

A very simple procedure for the inspection was mapped out by the Chief. The two men called at the back door of the home and asked permission of the

Providence Evening Bulletin (Courtesy the Providence Journal Co.).

Two members of the Providence Fire Department inspecting a basement and pointing to old furniture, paper and rubbish that may become a fire menace.

housewife to make a fire inspection of the basement of the dwelling. The housewife was asked to accompany the inspectors while making the inspection if her time would permit. Only the ordinary simple hazards found in basements were to be investigated. These included such items as the proper fire stopping of walls, cleaning of chimneys, rubbish, electric wiring, ashes in wooden barrels, and protection of the ceiling over the furnace. The hazards noted were pointed out to the property owner at the time of the inspection and corrections suggested. The literature on home dwelling hazards was then distributed.

A week prior to the opening of the campaign stories describing the purpose of the campaign and procedure to be followed were carried in the papers. The fact that the campaign was being undertaken purely for the benefit of the city as a whole and involving no compulsion or threat to any person or property owner was emphasized. Statistics on the losses in Providence showing the need for this campaign were published in the papers.

An interesting and unlooked for development was the fact that a great many home owners in the city immediately began cleaning up their basements, anticipating the visits of the firemen and being unwilling that they should discover a dirty or hazardous condition. From the start of the campaign on September 29 it was evident that the idea had the full support of the general public.

The campaign was pursued from September 29 to November 10, 1930, and a total of 77,076 dwellings were inspected. Of this number in only 228 cases were the firemen refused admittance. The remarkable effect of the campaign is perhaps most clearly demonstrated by the fact that during the

entire six weeks of the inspection only two cellar fires occurred throughout the city.

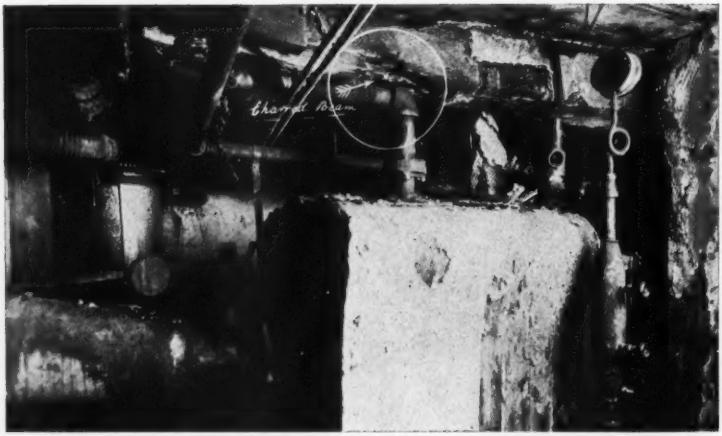
A real measure of the success of the work was afforded by the experience of the municipal incinerator. As soon as the inspections started its facilities were overtaxed by rubbish of every sort. For the six weeks period an average of 40 tons a day of waste material came in for incineration. During the first week of the inspection over 500 Christmas trees left from the previous Christmas were received. A total of some 3500 old mattresses came in. Ice chests, sofas and furniture of all descriptions, books, old clothing and newspapers by the ton were brought out of the basements of Providence.

The effect of the campaign was not limited to the cleaning up of the dwellings. As a corollary to the campaign considerable increased activity in cleaning up mercantile and industrial establishments was noted.

Because of the success of this campaign it is to be made an annual event in Providence. It is too early to show statistically the effect of this work on the dwelling house fires and losses in the city. No one can question, however, that a very substantial reduction in such losses will be the logical result.

ONE WAY TO HELP

Cartoon published by the Providence "Journal" during the home inspection campaign.



Unprotected Steam Pipe Starts Fire.

An unprotected steam pipe too close to a wooden beam in the basement of the Wellington Block in Edmonton, Alberta, was the cause of a fire on October 8, 1930. The beam, located directly over the boiler, was charred to a depth of three inches. It did not break into flame, due to the fact that the basement had no means of ventilation other than the door leading to same, which at all times was kept closed. The fire was noticed by the caretaker when he went down to attend to the boiler, just the red glow of the charred wood showing.

It is apparent from the accompanying photograph that an effort had been made to protect the beam above the heater with metal lath and plaster. This protection was obviously ineffective. An investigation after the fire revealed the fact that the boiler had been allowed to run dry. This perhaps had speeded up the ignition of the beam. This fire clearly emphasizes the importance of the protection of combustible ceilings above heaters and a proper clearance for steam pipes from woodwork.

The data regarding this fire and the photograph have been furnished through the courtesy of J. Booth, Fire Marshal of Edmonton (Member N.F.P.A.).

The Municipal Regulation of Oil Storage.

By Robert S. Moulton,
Technical Secretary, National Fire Protection Association.

The public in general is apprehensive of the fire hazards of gasoline and other flammable oils, but unfortunately has not grasped the actual facts of the situation and in considering the subject from the viewpoint of public safety the emphasis is often misdirected. A quart of gasoline brought into the kitchen for cleaning a pair of gloves may be more hazardous than an 80,000 barrel gasoline tank properly constructed and located. The large tank is in general under supervision of men familiar with the properties of gasoline and who have found by experience that it is good business to take proper fire prevention precautions. The woman using gasoline in the kitchen is ignorant of the properties of the liquid; she does not realize the explosive character of a mixture of gasoline vapor and air, nor does she know how easily it may be ignited.

Gasoline and other flammable oils are always potentially dangerous, but like other fire hazards, their use may be safeguarded. After many years' experience, methods of storage and handling these flammable liquids have been developed which tend to minimize the potential hazard, and through the application of recognized measures of fire prevention and protection the public safety from gasoline and oil fires may be reasonably safeguarded. It is the purpose of this article to urge an intelligent public viewpoint of this entire problem and to direct attention not merely to the properties where there is visual evidence of the presence of large quantities of gasoline and oil, but to other situations where the fire hazard may be actually far more acute.

Various other liquids such as ether and alcohol have hazards similar to gasoline and other petroleum products, and are properly subject to the same type of municipal regulation as applies to gasoline, kerosene and similar liquids. The principles discussed in this article are all applicable to flammable liquids in general, irrespective of whether they are derived from petroleum or other sources, but as gasoline is the flammable liquid encountered in the largest quantity, it has been convenient in this article largely to discuss gasoline with the understanding that the same comments are in general equally applicable to other flammable liquids.

Oil Supply a Public Necessity.

It might be desirable from the viewpoint of fire hazard to eliminate gasoline and oil altogether from our cities. We cannot do this. The use of gasoline and other flammable liquids is now almost universal and any measures instituted to promote the public safety in the use of these liquids must always consider the fact that a convenient supply of gasoline and oil is a

Where there is smoke there is fire, but in the case of an oil fire an enormous volume of smoke may be generated in a fire that does relatively little damage. The total cost of this fire, including chemicals used in its extinguishment, was about $500.

public necessity. Public safety measures should be adequate for public safety, but should avoid unnecessarily burdensome requirements, for such will merely impose an additional cost upon the general public as the users of gasoline and oils. We should fully recognize the fire hazard of large scale storage and handling of flammable liquids, but should remember that in the public mind this is often exaggerated and that as a practical matter there is sometimes a greater hazard in the relatively small scale handling of gasoline and oils in the home and in the hands of the small operator who has not the background of skill and experience possessed by the large oil companies.

Oil Tanks as Neighbors.

An oil tank is not ordinarily considered a desirable neighbor. It is an unsightly addition to a residence district and it is not surprising that a storm of protest arises from the residents of any district where a large scale oil storage property is proposed. It is not the purpose of this article to defend oil tanks from an aesthetic viewpoint, but to urge that where the objection to an oil storage property is based on the appearance of the tanks the objection should be voiced on this ground. As a practical matter, the aesthetic objections to an oil tank location are rather intangible and difficult to support in court. Fire hazard is a much more tangible and definite thing. We find in public hearings on petitions for the construction of oil tanks in or adjoining residential districts that the fire hazard is the point largely emphasized,

Gasoline and oil storage is only one of many types of hazardous occupancies that may menace surrounding property in case of fire. Wood was the fuel for this fire.

although if we may judge from conditions in their own homes and business properties, many of the objectors really know or care very little about the fire hazard. They merely seize upon it as a method of attack upon the proposed oil tanks which, for altogether different reasons, they do not care to have in their district. This is an unfortunate situation and tends frequently to confuse the issue.

Public opposition to an oil tank location on the grounds of fire hazard is frequently illogical. The writer was recently asked by a Chamber of Commerce to inspect the site of a proposed gasoline tank the erection of which had been opposed in a petition signed by several hundred residents of that district of the city. It was an old oil storage property dating back many years, with a number of ten thousand gallon gasoline tanks housed inside wood frame structures with the gasoline handled by air pressure instead of by pumping. This arrangement represented a severe fire hazard—one which would not be found in a more modern installation. These tanks had been in the same location for twenty years. During this time no objection had been raised to their presence by residents of the vicinity, presumably because the tanks were inside buildings and could not be seen, although it must have been known through the district that gasoline was handled there. The proposed

tank was to be a modern all-steel structure and its erection was to be the first step in a program of modernization of the plant which would have tended greatly to reduce the fire hazard.

Considering the matter solely from the viewpoint of fire hazard and giving no thought to unsightliness or possible unpleasant odor, there is, of course, a definite fire hazard in having an oil tank as a neighbor. Modern oil properties, however, have a good fire record and the serious fire is of infrequent occurrence. As far as the "exposure" to adjoining property is concerned, the fire hazard of a hay barn is probably greater than that of a modern gasoline tank under competent management.

The Classification of Flammable Liquids.

The flash point of a flammable liquid is the lowest temperature at which it can give off combustible vapors in dangerous quantity, as measured with a standard testing apparatus. The flash point of gasoline is zero Fahrenheit, or lower, that of kerosene above 100° F., and that of lubricating oils in general ranging above 300° F. Flash point is only one of several characteristics determining the relative hazard of flammable liquids, such as volatility, explosive range, and vapor ignition temperature, but it is a convenient measure of hazard and is generally used in differentiating between the hazards of various classes of liquids.

The lower the flash point the greater is the hazard, but in handling flammable liquids it is unwise to rely on fine distinctions of flash point, and any liquid which has a flash point below ordinary atmospheric temperature should be treated with due respect. For purposes of municipal regulation of flammable liquids it is necessary to set some definite upper limit of flash point, with liquids having higher flash points not classed as flammable. The National Fire Protection Association has set this figure at 187° F., and the provisions of its suggested ordinance are designed only to apply to liquids having a flash point below this figure.

Analyzing the Hazard as to Quantity and Quality.

The seriousness of any individual fire hazard depends in general upon two factors, one the probability of the start of fire, and the other the potential extent of fire once started. With flammable liquids, the probability of the start of fire depends upon the character of the liquid and the method of handling, the presence or absence of potential sources of ignition, and the personal element. The total quantity stored has relatively little influence upon the probability of the occurrence of fire; an open flame will ignite a hundred gallons or a thousand gallons of gasoline with equal facility.

Once a fire is started, the extent of course depends upon the quantity of liquid, and where tanks collapse and gasoline flows freely over the ground there is a great difference between a 500-gallon and 50,000-gallon fire. Where burning takes place in an enclosure, the rate of burning depends largely upon the rate of air supply to the burning surface, and as a practical matter a

larger quantity of liquid is likely to mean a fire of longer duration rather than a more severe fire at any one time. Large oil fires sometimes burn for days before the oil is consumed.

The community fire hazard of an oil property is greater when the quantity of oil stored is increased, but the increase in hazard is not in proportion to the amount of increase in quantity of oil stored. If it were possible to measure in exact figures the community fire hazard of an oil storage property, it might be found that a 100% increase in quantity of oil would mean only a 10% increase in hazard. When considering applications for the installation of oil storage tanks, the municipal authorities should be much more concerned with the general character and method of operation of the property than with the mere size of the storage in gallons.

Indoor vs. Outdoor Storage.

The fire hazard of storage of flammable liquids inside buildings is much greater than that of similar storage outdoors. In buildings, there is not only the additional property value exposed to fire damage, but also an increased hazard owing to the danger of accumulation of flammable vapors. Outdoors, breezes and natural drafts tend to dissipate vapors as they are formed, but in buildings, unless special attention is given to the method of handling flammable liquids and to ventilation, there is always danger of accumulation of flammable or explosive vapors. For this reason the storage and use of flammable liquids indoors is properly subject to more stringent requirements than would apply for outdoor storage.

In the case of paints, varnishes, etc., some of which contain solvents giving the product the characteristics of a flammable liquid, the vapor hazard does not appear as long as the liquids are handled only in the original sealed containers, and for this reason it is usually considered unnecessary to apply any special regulations to the hardware store, for example, which sells paints and varnishes in original sealed cans. Where mixing is done, and the liquid paints or thinners exposed to air, there is a definitely increased fire hazard.

The Proper Location of Oil Storage Properties.

Oil storage properties should be located away from residence districts where they are not wanted. This is primarily a matter of zoning requirements. From the viewpoint of fire hazard as well as the desirability of the oil tank as a neighbor, it might be well if all oil storage properties could be located in the open country well away from cities and remote from water ways, roads and railroads. As a matter of fact, the same argument might be applied to a number of other types of hazardous business which are commonly found within the limits of our cities. It is obvious that such remote location is impracticable. Oil tanks should, of course, be kept outside of the congested and high value mercantile districts. They should be in outlying industrial districts where their operation is economic and where their presence

A loss of life and the destruction of a substantial part of the business property of this town resulted from the apparent disregard of recognized fire-safety precautions. The oil tanks were located too close together, too near the railroad right of way, and adjoining property without dikes and with no available foam or other special protection for oil fires.

is consistent with the type of other occupancy of the district. It is a common requirement of cities to prohibit the location of oil storage properties in the business center, or rather to require all such oil storage in the business center to be underground, which has the same result as far as public safety is concerned.

Distance to Adjoining Property.

A question frequently raised in connection with the location of large oil storage properties is the distance which should be maintained between oil tanks and other property in order to avoid undue hazard to the buildings adjoining the oil tank. It is not possible to answer this question definitely except on the basis of the local conditions. The size and character of the oil tank, the dikes or fire walls provided to stop the flow of oil in case of escape of oil from the tank during a fire, the topography of the ground, and other features, all have a bearing. In the Flammable Liquids Ordinance of the National Fire Protection Association this matter is left to the judgment of the fire chief or other municipal authority as follows:

SECTION 47. In case of tanks for the storage of Class I, II and III liquids at marketing stations, wholesale storages, port terminals and other properties where flammable liquids are stored in quantities the distance from the line of adjoining property which may be built upon shall in no case be less than set forth in Table 1 nor less than double these distances in the case of tanks for the storage of crude petroleum. In particular installations these distances may be increased at the discretion of the authority having jurisdiction after consideration of the special features such as topographical conditions; nature of occupancy and proximity to buildings on adjoining property and height and character of construction of such buildings; capacity and construction of proposed tanks and character of liquids to be stored; degree of private fire protection to be provided, and facilities of the fire department to cope with oil fires. Consideration of these features shall also determine the distances for tanks of capacities of over 50,000 gallons.

TABLE 1—MINIMUM DISTANCE OF OUTSIDE ABOVE-GROUND TANKS FOR CLASS I, II AND III LIQUIDS OTHER THAN CRUDE PETROLEUM TO LINE OF ADJOINING PROPERTY WHICH MAY BE BUILT UPON.

Capacity of Tank, Gallons	Minimum Distance to Line of Adjoining Property which may be built upon
0 to 12,000	10 feet
12,001 to 24,000	15 feet
24,001 to 30,000	20 feet
30,001 to 50,000	25 feet

Crude oil usually contains a certain percentage of water, which may suddenly boil over when the oil is heated in burning, greatly increasing the hazard of fire in a crude oil tank as compared with the hazard of a fire in a tank of gasoline or other refined petroleum product. For this reason crude oil tanks should be located farther away from adjoining property than is required with other tanks, and various other special precautions should be taken. Crude oil storage will ordinarily be found only near oil wells and at refineries.

Wood is not a suitable material for the construction of any part of an oil tank. Wooden roofed tanks have been responsible for most of the major oil conflagrations in the past. Modern practice is to use all-steel construction.

Underground vs. Above Ground Storage.

Gasoline and oils in underground tanks present practically no fire hazard in so far as the storage itself is concerned. A tank buried under two or three feet of earth and protected from mechanical injury by a concrete slab which will take the load of a truck or any heavy weight which may be placed above the tank, is practically immune to fire danger. (A few recorded fires or explosions in underground tanks are in the nature of freak cases which are very much the exception.) Underground storage is much the best from the fire hazard viewpoint and is commonly required wherever the storage must be located in the congested high value districts of cities. Domestic oil-burning installations likewise largely use buried tanks where the quantity of storage is greater than can be safely located in the basement.

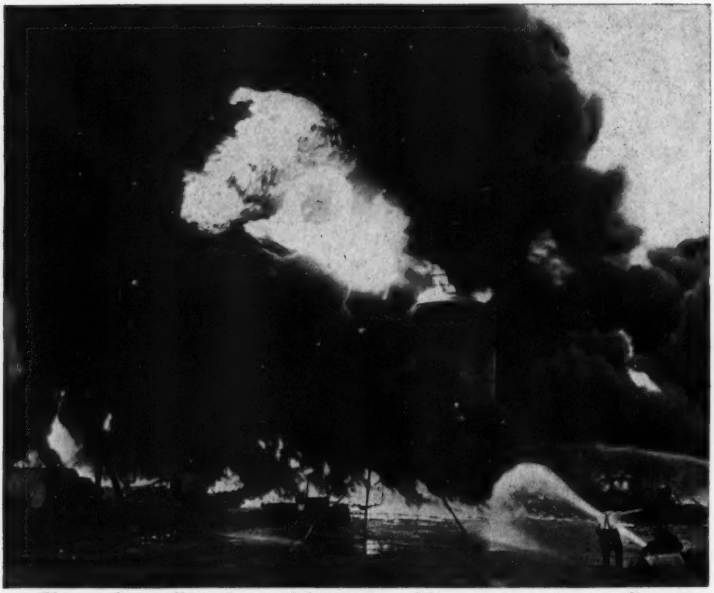
With the gasoline underground, the hazard of the storage itself is eliminated, but there remains, of course, the hazard of handling the gasoline to and from the tanks. The tanks must be filled by deliveries from the tank truck or in some other way, and the gasoline likewise must be withdrawn from the tank for use. Carelessness in either filling the tanks or withdrawing, permitting leakage or the escape of gasoline vapors, is obviously a potential hazard. It should be noted that this hazard is one which depends upon the operating personnel and the character of the supervision given the property rather than upon the capacity of the underground storage in gallons.

Underground storage tanks, in order to be safe, must be located at a safe distance from basements or any pits into which gasoline might flow in case of any leakage of the tank. As long as the tank is below any surrounding basements or pits there is no restriction as to the size. Where the top of the tank is above the level of near-by basements or pits, the safety requirements call for limitation of the size of the tank in proportion to the distance from the building. There is no danger in locating a tank under the basement floor provided there are no lower basement levels near by and provided that the filling and vent connections are outside the building rather than in the basement.

While underground storage is unquestionably the safest method, it is practicable only for moderate quantity storage. Where large quantity storage is involved, the expense and mechanical difficulties of underground storage are such as to make this impracticable and above ground tanks are used. Above ground tanks of proper design and construction, correctly located, and provided with dikes or fire walls to prevent the flow of oil towards adjoining property in case of leakage of the tank, have, as previously indicated, a relatively good fire record.

All-Steel Gas-Tight Tanks.

Wood is a valuable construction material, but it is not suitable for the construction of any part of an oil tank. The former use of wood in oil tank

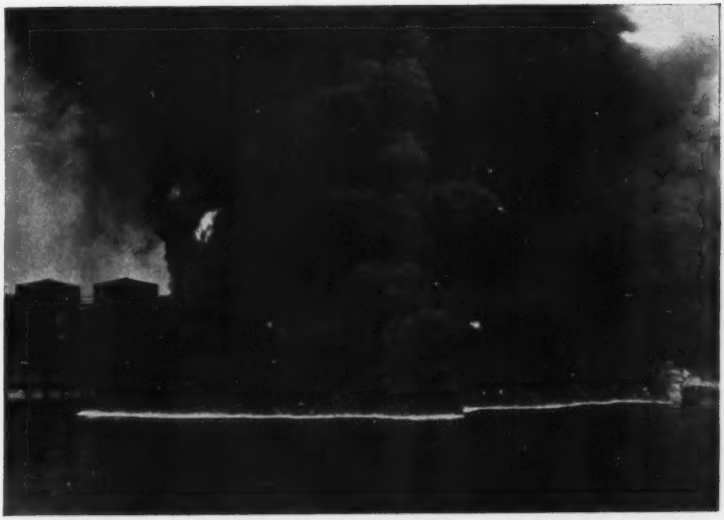


The modern all-steel gas-tight tank, with proper vents, usually comes through a fire undamaged. This picture shows gasoline vapor burning above the tank, which retained its contents until consumed and was still standing after the fire. The general fire around the tank seen in the picture was chargeable to various substandard features in other portions of this oil storage property.

construction has a good deal to do with the popular distrust of oil tanks in general. All-wooden tanks have not been used for many years, but the construction of steel tanks with wooden roofs has only been abandoned during the past ten years. A wooden roofed tank is dangerous from the fire hazard viewpoint and it is in tanks of this character that the majority of the oil conflagrations have occurred.

Modern practice is to construct all-steel tanks tightly riveted or welded to prevent leakage or the escape of vapors, and provided with proper venting arrangements to relieve any excessive pressure. Such a tank usually comes through a fire with very little damage. Fire occurring outside such a tank will heat the liquid and boil off the vapor which will issue from the vents and burn there harmlessly as a jet of gas. After the fire is over, the tank may be still half or two-thirds full. Of course, with improperly designed or constructed tanks, and under occasional exceptional combinations of circumstances, there may be serious trouble even with an all-steel, gas-tight tank, but this is unusual.

Features of particular importance in above ground storage properties, in addition to all-steel, gas-tight tank construction, separation from adjoining



Burning gasoline floating on the surface of the water serves to spread fire to shipping and waterfront property. Proper dikes around tanks near rivers and harbors retain the liquid in case of leakage or failure of tanks and greatly reduce the danger of fires like that shown above.

property and dikes, are adequate venting facilities, and proper separation between tanks, warehouse buildings, and "loading racks" where tank trucks are filled.

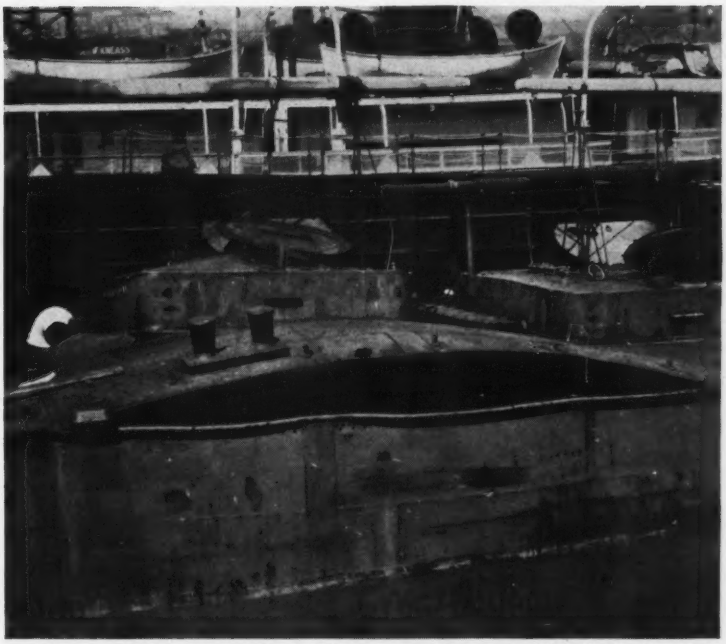
Storage Near Rivers and Harbors.

Gasoline or oil tanks adjacent to rivers and harbors present a special problem in that in the event of failure of tanks and escape of oil, it may float on the surface of the water and spread fire with great rapidity to shipping and waterfront property. Where feasible to do so, it is advisable to locate tanks downstream, or so that the prevailing winds may carry burning gasoline on the water away from waterfront property. Obviously, tanks should not be located on piers or wharves of combustible construction.

The hazard of floating gasoline can be guarded against by surrounding waterfront tanks with dikes to contain the liquid in case of any leakage from the tank. Where oil pipes extend to piers to connect with ships transporting oil or for fueling purposes, care in operation and proper valves to minimize the quantity of oil released in case of leakage of the hose connecting with the ship, serve to reduce the hazard to a reasonable minimum.

The presence of any oil on the water, even heavy oil that is not readily flammable, is undesirable from the fire hazard viewpoint, because wooden piling and pier substructures are much more susceptible to fire when oil coated. The discharge of oil on navigable waters is prohibited by State and Federal legislation.

Oil discharged on river or harbor waters forms an oily coating over wooden piling and pier substructures, increasing the fire hazard. Laws and ordinances prohibiting the discharge of oil on river and harbor waters should be strictly enforced.



The results of a vapor explosion in a supposedly empty ship's tank. Thorough cleaning of gasoline and oil tanks, followed by tests of the atmosphere in the tank prior to entering for making repairs, should prevent accidents like this.

Gasoline Explosions.

There is a popular fallacy that liquid gasoline is explosive. As a matter of fact, as long as the gasoline stays in the liquid form there is no danger of an explosion. It is only when it is vaporized and the vapor mixed with air in certain proportions that it becomes explosive. Lack of knowledge of this simple fact, which is illustrated by the everyday operation of the ordinary automobile engine, has been responsible for a good deal of unnecessary fear about the storage of gasoline in closed containers, and at the same time for taking foolhardy chances with gasoline vapor. The ordinary gasoline tank contains so much vapor above the liquid level, with little or no air present, that the mixture is too "rich" to explode. The supposedly empty tank, however, may contain a highly explosive mixture of gasoline and air vapor. A tank from which the liquid has been removed and air admitted may still contain a small quantity of liquid which will give off sufficient vapor to form an explosive mixture ready to be ignited by any chance spark. A number of disastrous explosions have occurred in oil tanks in ships, which have been supposedly emptied preparatory to repair operations, but where sufficient liquid remained to form an explosive mixture. Modern practice is to use great care

in cleaning a gasoline or oil tank. It is thoroughly washed out, steamed to remove any remaining vapors, and before men are sent inside the tank to do any work the atmosphere is tested to make sure that it is safe.

When gasoline tanks are exposed to severe external heat, pressure is generated just as in a steam boiler, and unless a suitable vent is provided, they may explode just as steam boilers sometimes explode. This type of explosion is not a "gasoline explosion" in the ordinary sense of the term, but a pressure rupture of the container from internal pressure, which may occur with water or any other liquid in a closed container subjected to heat. It is to avoid this danger that vents are required on all oil tanks.

Gasoline vapor is heavier than air and where there is no special ventilation it will flow along the floor, through doorways and along the ground, sometimes to be ignited at a long distance from its point of origin. This point should always be remembered in connection with the use of gasoline in any quantity. This is an insidious hazard, for vapor may collect in the bottom of pits or near the floor in buildings, not reaching high enough to be detected by the sense of smell of a man walking into the building, but nevertheless present in sufficient quantity for a serious fire or explosion if ignited by a chance spark, such as that which might be struck by the iron nail of a shoe against a concrete floor.

Kerosene does not give off explosive vapors in dangerous quantities at ordinary temperatures. This is the reason that there is so much less hazard involved in the use of kerosene than gasoline. Kerosene, however, when it is heated to something above 100° F., or in other words above its "flash point," does give off explosive vapors and has fire hazard characteristics similar to gasoline.

Familiarity Breeds Contempt.

As is the case with other fire hazards, men handling gasoline and other flammable liquids every day tend to become careless and neglect necessary fire prevention precautions. This is probably the principal reason for the fires that occur in connection with gasoline and oil storage, but it is a cause of fire that is readily preventable, as has been demonstrated by the experience of the larger oil companies which insist upon strict observance of fire prevention precautions by their employees and make smoking a cause for instant dismissal.

Men are sometimes encountered who say that gasoline cannot be ignited by a cigarette, and who will even offer to demonstrate this by experiment as justification for their smoking while handling gasoline. It is true that under average conditions gasoline may not be ignited by a burning cigarette; ignition takes place only when brightly glowing tobacco comes in contact with a gasoline vapor and air mixture of favorable proportions. A thousand cigarettes may be smoked by a man handling a gasoline hose at a filling station without meeting conditions favorable to fire, but the thousand and first

may cost him his life. "No Smoking" rules cannot be too strictly enforced where gasoline or other flammable liquids are handled.

Ignition by Static Electricity.

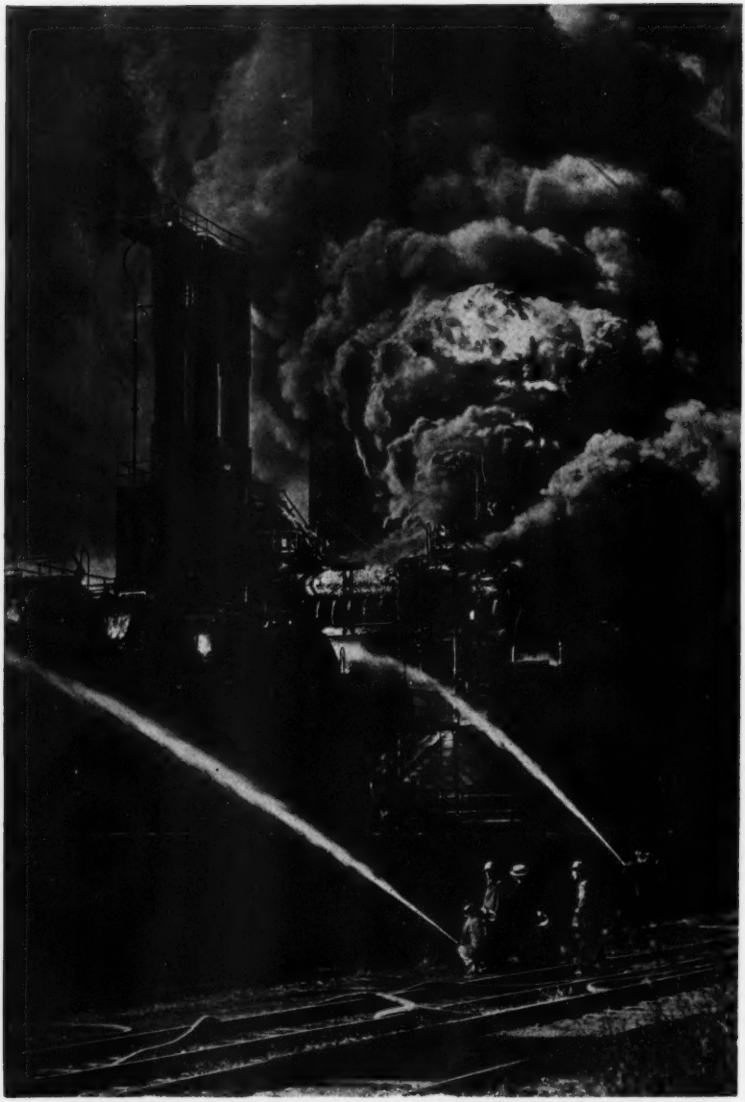
The sparks made by rubbing a cat's back, or that jump between your finger and a metal doorknob after you walk over a rug or carpet on a dry winter day, are called "static" sparks. Such sparks of static electricity are frequently sufficient to ignite the vapors of gasoline or other flammable liquids, and explain the gasoline fires and explosions that sometimes occur with no apparent source of ignition present. Static electricity may be generated by the rubbing or friction of any substance which is not a conductor of electricity, or by the flow of fluids. Pouring gasoline from a pail into a tank sometimes causes a static spark that ignites the gasoline vapor. The way to prevent sparks of this kind is to maintain metallic contact between the pail and the tank, so that electrical charges will have no opportunity to accumulate. For this reason the metal nozzle of the gasoline hose used to fill the automobile tank should always be inserted in the fill opening to make metallic contact with the tank. Electrical "grounding" of all objects likely to accumulate static charges is standard practice for the prevention of static sparks, and should be insisted upon wherever flammable vapors are present. If the relative humidity of the atmosphere is high, static electrical charges do not accumulate, and for this reason artificial humidification is an important fire prevention measure in dry cleaning establishments and in manufacturing plants where there is a flammable vapor hazard.

Other Sources of Ignition.

Other sources of ignition, smoking, open lights and fires, etc., are so obviously hazardous in the presence of flammable liquids that ordinary common sense furnishes the only fire prevention guide necessary. The hazard of electric lighting and power equipment is not always so obvious. Ordinary electrical equipment may cause small sparks in operation, which are harmless in the usual building, but a serious hazard in the presence of gasoline or other flammable liquids. A special type of wiring and equipment should be used, especially designed for safe operation in the presence of flammable vapors. This is commonly required by electrical ordinances, and the National Electrical Code has a special section dealing with locations where flammable vapors may be present.

Home Dry Cleaning.

The fire and explosion hazard of gasoline is most pronounced under conditions where the liquid can readily evaporate and the vapor mix with air. The home use of gasoline for dry cleaning purposes represents an extreme hazard. Here clothing is saturated with the liquid which evaporates as the clothing dries. The slightest spark—a pilot light of a gas stove or even the friction of rubbing garments, is sufficient to ignite the vapor. Hundreds of women and children have lost their lives because of the use of gasoline in



The oil refinery presents a fire hazard much greater than that of ordinary oil storage properties. Oil refineries should be located outside of cities or in districts especially zoned for hazardous occupancies.

Gasoline was responsible for an explosion and fire that cost the life of the woman who was cleaning curtains in this kitchen. The sale of gasoline for home dry cleaning purposes should be prohibited.

this way. The sale of gasoline for home dry cleaning purposes or any similar home use should be prohibited, particularly so in view of the fact that non-flammable dry cleaning liquids are readily available.

The professional dry cleaner understands the hazards of the use of gasoline and has his property safeguarded. Gasoline is seldom exposed in the open air, most of the operations being carried on in closed machines. Furthermore, dry cleaners are now largely using special cleaning liquids similar in cleaning properties to gasoline, but without the same fire and explosion hazard.

The Industrial Use of Flammable Liquids.

Many types of manufacturing plants use flammable liquids to a greater or less degree in connection with their operations. They may use gasoline or other petroleum oils, alcohol, or various special solvents which are classed as flammable liquids. The extent of the hazard of this use depends on the character of the liquid and the way it is employed. Any process which permits dissipating flammable or explosive vapors through buildings is obviously hazardous. This is a special problem which requires expert fire protection engineering attention and which cannot be discussed within the limits of this article. In extreme cases the hazard may be such that the factory should be placed in a remote location, but ordinarily it is possible through the application of recognized fire prevention measures to so protect the use of flammable liquids in manufacturing operations that public safety is amply guarded.

Oil Refineries.

Oil refining is in general a hazardous process which should be located either outside of cities or in designated industrial districts reserved for

hazardous industries. In the oil refinery petroleum is handled under high pressure and elevated temperatures, and fire heat is provided as an essential part of the process. Gasoline or oil under high pressure is separated from the furnace only by the shell of a drum or the wall of a pipe, any failure of the steel permitting the discharge of oil into the furnace. Skilled operation by competent personnel, of course, does a great deal to mitigate the hazard. Oil refineries destroyed by fire cannot operate and it is to the interest of the operating personnel to prevent fire. Nevertheless the oil refinery must be considered in the class of a hazardous occupancy which, from the viewpoint of public safety, should be located either outside of the city or in a district specifically zoned for hazardous industries.

Gasoline Filling Stations.

The location of gasoline filling stations in residential or semi-residential districts is frequently opposed by adjoining property owners. Filling stations of the usual type with tanks underground, with pumps of approved type, and with concrete and other fire-resistive material predominating in the construction, present a relatively small fire hazard. There is, of course, the danger of carelessness in filling the underground tank from a gasoline tank truck, and the transfer of gasoline from the pump to the automobile tank involves the possibility of fire, but in the opinion of the writer the community fire hazard is not appreciably increased by the presence of a modern gasoline filling station under competent management. There are gasoline filling stations which should be considered a distinct fire menace, where improper construction and location of equipment, accumulations of combustible rubbish, and generally careless personnel make for conditions veritably inviting fire. Such conditions are, however, the exception and should be taken care of by the proper enforcement of municipal fire-safety regulations.

Crank Case Drainings.

The used oil drained from automobile crank cases contains more or less gasoline, the amount depending upon weather conditions and the method of operation of the individual automobile engine. Crank case drainings should always be handled with this in mind, and should not be used for oil-burner fuel because the gasoline content renders such use distinctly hazardous.

The disposal of used crank case oil presents a troublesome problem. The proper method is to have it collected from the gasoline filling stations by some central agency that can handle it safely and put it to some useful purpose rather than leaving it in the hands of the individual filling station where it may be used in a home-made oil burner or surreptitiously poured into sewers. At least one city has a free municipal collection of crank case drainings, operated like the municipal garbage collection. In other cities it is collected by the larger oil companies, and sold for various special uses. Equipment is now available for purifying this oil so that it may be used again as a lubricant.

Gasoline and other flammable liquids should be kept out of sewers. Oil traps should be located in the drains from garages, dry cleaning plants, and other establishments using flammable liquids.

Keeping Flammable Liquids Out of Sewers.

The disposal of waste gasoline and other flammable liquids is frequently a problem in garages, dry cleaning establishments and the like. Emptying into sewers is an easy method of disposal, but highly hazardous, as has been demonstrated by the experience of various cities that have had serious sewer explosions. Wherever garages or other establishments have drains leading into sewers, oil traps should be required to separate gasoline and oil from the water and prevent the escape into the sewer.

Gasoline Tank Trucks.

The distribution of gasoline to filling stations and for the general uses of the community involves its transportation by tank trucks through city streets. This involves an element of hazard in case of collision or other accident to the tank truck. Where gasoline escapes into the street and is ignited in some way, serious consequences may result. Proper construction of tank trucks (see N.F.P.A. pamphlet on this subject) does a good deal to reduce this hazard, but cannot eliminate it altogether. It is not practicable to prohibit the operation of tank trucks in the city streets. The supply of gasoline which they furnish is a public necessity, and tank trucks are probably the safest practicable means of transportation.

Tank Cars.

The tank car containing gasoline or other flammable oil presents a hazard on the railroad right of way which is comparable to that of the tank truck in the street. The design and construction of tank cars is subject to careful

supervision on the part of the Committee on Tank Cars of the American Railway Association. A railroad wreck involving tank cars has dangerous possibilities, however, no matter how well constructed the tank cars. The transfer from tank cars to distributing tanks in cities is a point of some hazard. This operation should be kept out of the high value districts of cities in so far as possible, although it is not reasonable to prohibit it altogether.

Pipe Lines.

Gasoline and other oils are now transmitted long distances through pipe lines which extend from the oil fields to large cities which are centers of distribution and consumption. Where the pipe line passes through the open country it is not a cause of concern, but where it comes into the city, particularly where it passes through city streets, there is an element of hazard. Thus far there have been few, if any, fires or accidents incident to the location of pipe lines in city streets. This may be due to a relatively small hazard or simply due to the fact that there has not as yet been sufficient experience with the location of pipe lines in cities to permit drawing conclusions. A pipe line in the city street may be subject to mechanical injury owing to street excavations for other pipes or it may fail owing to the effects of vibration due to the street traffic. Substantial construction of the pipe line buried well beneath the street, protected by a substantial pavement or the pipes otherwise protected from mechanical injury, should largely control this hazard. In case gasoline does escape from a pipe under pressure running through the city streets, a continued leak may saturate the ground for a considerable distance, seep into the basements of adjoining buildings, and cause a great deal of trouble. We have a somewhat comparable experience in the piping of illuminating gas through the city streets. Gas pipes are similarly subject to breakage and gas is similarly flammable. The difference is that gas tends to rise and escape into the air, while gasoline will remain in the ground.

Gasoline and Oil Stoves.

The old-fashioned kerosene oil stove has been the cause of a great many fires. Despite the frequent reports of oil stove "explosions," scientific investigation shows that true explosions seldom if ever occur. Fires from oil stoves largely occur from placing stoves too near combustible material, from carelessly overturning them, and from flare-ups due to the use of dirty or defective stoves. When a stove is overturned and burning kerosene flows out on the floor, the fire flashes so rapidly that it is frequently described as an explosion. This is an important hazard wherever the use of oil stoves is general, but one apparently not susceptible to municipal control except through public education and through the activities of Fire Department inspectors.

Gasoline stoves for cooking are convenient for use where other types of stoves are not available, but are more hazardous than gas, electric, or coal-burning stoves. The hazard of the stove itself can be minimized by the use of

stoves listed by Underwriters' Laboratories and installed in accordance with the Regulations of the National Fire Protection Association, but the hazard of storing and handling the gasoline supply cannot as a practical matter be eliminated.

Oil-Burning Equipments.

Oil burners in their initial development were a cause of considerable concern to fire prevention authorities, but properly constructed burners, bearing the label of Underwriters' Laboratories as evidence of their proper design and construction, installed in accordance with the recommendations of the National Fire Protection Association, have enjoyed a relatively favorable fire record. An oil-burner ordinance enforced by the Fire Department or other local authority is, however, in general necessary to guard against the hazard of home-made and other unapproved oil burners and unsafe installation.

Fire Extinguishment.

Gasoline and oil fires cannot ordinarily be put out with water, but there are available extinguishing methods for readily handling such fires. There are special types of extinguishers for oil fires, including among others carbon dioxide, which in effect blows out the fire by the use of a non-combustible gas; carbon tetrachloride—a special extinguishing liquid used for small gasoline and oil fires; and foam—a frothy substance somewhat resembling a brown soap suds which will float on the surface of the oil excluding the air and thus smothering the fire. This foam is produced by the use of special chemicals with water and it may be supplied either from a portable fire extinguisher or by a large size fire department hose stream. It is a common practice in the larger cities of the United States for the fire department to have as a part of its equipment a foam generator, together with a supply of foam chemicals, for use in combating gasoline and oil fires. The larger oil storage properties frequently provide their own foam protection with fixed installations to handle any fire which may occur in their tanks. Sometimes private foam protection is required by the city authorities, depending upon the local conditions. It is often felt that an oil tank may with safety be located nearer to adjoining property where adequate foam protection is provided than where no such protection is available.

While water will not ordinarily extinguish gasoline fires, there are many situations where the application of water through automatic sprinklers is considered excellent protection for gasoline and other flammable liquid hazards. In garages and airplane hangars, for example, it has been shown by test and by actual fire experience that automatic sprinklers are very effective. The burning gasoline may not be immediately extinguished, but the water spray keeps the interior of the building cool and makes the flame harmless. It prevents the development of sufficient heat to rupture gasoline tanks and thus release additional fuel to feed the fire. Likewise in various industrial occupan-

cies where the flammable liquids hazard is pronounced, automatic sprinkler protection has been found effective.

The N.F.P.A. Regulations.

The National Fire Protection Association, in accordance with its general policy of furnishing public guidance in the control of all fire hazards, has given careful study to various phases of the hazards of flammable liquids, and has published recommendations that may be made the basis for municipal ordinances or regulations, and are available for guidance of all those interested in eliminating the fire hazards in their own properties. These recommendations are drawn by technical committees including representation from fire insurance companies, the oil industry and other industries affected by the rules, fire chiefs and governmental authorities. They are generally accepted as the recognized guide to good practice in the control of fire hazards. The recommendations are not designed to give 100% fire safety, for this would be impossible without drastic and burdensome restrictions. They are designed, rather, to provide reasonable public safety, without imposing any undue burden upon industry or the general public. The publications in this class, of particular interest in connection with the flammable liquids hazard, are as follows:

Suggested Ordinance Regulating the Use, Handling, and Sale of Flammable Liquids and the products thereof, including requirements for automobile gasoline service or filling stations, and appendix on rooms, cabinets and outside houses for storage of flammable liquids.

Marine Oil Terminals, Recommended Good Practice.

Automobile Gasoline Tank Trucks, Recommended Good Practice.

Oil Burning Equipments, Regulations for installation and operation, with separate treatment of industrial and domestic equipment.

Suggested Oil Burner Ordinance.

Gasoline Stoves.

Dry Cleaning and Dry Dyeing Plants.

Paint Spraying and Spray Booths.

The Spray Application of Flammable Finishing Materials.

Internal Combustion Engines (gas, gasoline, kerosene and fuel oil).

Finishing Processes (dip tanks and other industrial finishing processes involving flammable liquids).

First Aid Fire Appliances (extinguishers for oil fires).

Foam Extinguisher Systems.

Carbon Dioxide Fire Extinguishing Systems.

National Electrical Code (Article 32).

Fire Effects on Fire-Resistive Construction.

By Frank Burton,
Consulting Engineer (Member N.F.P.A.).

The absorption of heat by various materials of fire-resistive building construction and the influence of heat absorption in reducing fire temperatures were discussed by the author in "Fire Temperatures and Building Construction," published in the October QUARTERLY (Vol. 24, No. 2, p. 163). It was shown in this article that the heat absorption by the interior surface of a building reduces the temperature of outgoing smoke and gases from a fire, and transmission of heat through floor slabs and other elements of building construction tends to reduce the temperature at critical points, with the result that ordinary fires may result in the development of temperatures in structural members much lower than have commonly been assumed.

A great deal of fire damage is due to causes other than the effect of heat in softening structural steel and the transmission of dangerous temperatures through floors and walls. The expansion of construction materials under fire temperatures, and particularly unequal expansion due to unequal heating, appears to be a much more important factor, the seriousness of which seems largely to have been overlooked in current requirements for the design and construction of fire-resistive buildings.

Expansion of Steel.

Steel expands about eight parts in a million for each degree Fahrenheit, or eight parts in a thousand if raised 1000 degrees, or just below the point where it ceases to have its working strength. In 100 feet this amounts to 9½ in. Thus it can be seen that a bare steel truss of any considerable length if heated even to 500° F. or 600° F. can force the walls of a building out of plumb long before any other serious damage will be done. In fact, trusses have been known to wreck walls, although the general temperature inside of the building did not become high enough to cause general ignition of combustible contents. Expansion of fireproofed steel columns is not serious, but when beams expand they bend the columns which are restrained above and below, unless the fire occurs on the top floor of the building. We have very little data as to the temperatures attained by steel beams fireproofed with 1½ in. to 2 in. of concrete, but from such tests as are available, it appears that a rise of 300° F. may be expected at the end of 2½ or 3 hours for beams projecting only 2 or 3 inches below the slab, and for beams projecting 10 or 12 inches this temperature rise would probably be attained in from 1 to 1½ hours. I estimate that in a building two or more stories high and 80 to 100

This article, further developing the thought of the article in the October QUARTERLY, page 163, is extracted from an address by the author at the 1930 meeting of the Building Officials Conference—Ed.

The burning and general failure of concrete under severe fire exposure. This damage, resulting from the burning of a large quantity of rubber cement, occurred in a building of first-class construction despite the best efforts of the local fire department.

Damage to fire-resistive floor construction due to spalling of concrete and unequal expansion. Note distortion of the ceiling in the background of this picture.

feet long in which any floor except the top is exposed to a fire sufficiently severe to raise the temperature of the steel beams 300° F., the bending of the wall columns, if continuous from the floor below to the floor above, will cause them to fail.

Expansion of Concrete.

Concrete expands about seven parts per million per degree Fahrenheit, and is, therefore, just as capable of thrusting out walls as steel, but the much greater masses of concrete used, together with its much lower conductivity, delay the expansion for a considerable period. When, however, massive concrete structures are heated for sufficient periods to insure thorough heating of the floor slabs, serious damage is done by expansion. For example, a stone concrete slab heated to about 2000° F. at the end of 4 hours will have a temperature of 1800° at $\frac{1}{4}$ in. from the bottom and 250° a quarter of an inch from the top.* The net average temperature rise would be 965° F. and the expansion for a building 10 ft. by 200 ft. would be 8 in. across its width and 1 ft. 4 in. in its length. Also, the expansion of the bottom of the slab, if free to move, would be 1 ft. $2\frac{1}{2}$ in., while the expansion of the top of the slab would be only $1\frac{5}{8}$ in., or about 1 ft. less. This large difference in expan-

*Red Book of the British Fire Prevention Committee, No. 251.

sion must cause the slab to curl, but if it is continuous and the curling is restrained by column reactions bending and shearing stresses will be produced instead of actual curling.

If a piece of concrete is heated 100° F. and then compressed to its original length, a pressure of 1400 pounds per square inch will be required, assuming the usual modulus of elasticity of two million. By assuming a given set of conditions it is possible to calculate the radius of curvature and the forces necessary to produce an equal and opposite deflection. From these data the flexure and shearing stresses can be calculated. In a typical continuous concrete flat slab building of commercial size I estimate that the slabs will fail as a result of tensile stresses in the top of the slab near the inner column when the temperature difference between the top and bottom is 500° F. or less.

Experience has shown that continuous concrete slab buildings when exposed to large unrestrained fires actually shear (or more properly tear) through slabs even 8 and 9 inches thick and the sheared edges telescope one over the other. It is evident then that the mere fact that such slabs resist a four-hour fire when placed over a small test house is no reason to believe that a building containing such slabs will really resist a severe fire for four hours or even two hours, since larger temperature differences than 500° F. have been observed within two hours during tests. In fire tests the slabs curl, but as they are not restrained they are not broken.

Expansion of Brick.

Brick expands when heated about six parts per million per degree Fahrenheit. Under test conditions small sized brick and tile walls 12 in. or more thick will resist fires for six hours or more. Practical experience confirms this in the case of walls stayed at frequent intervals with floor systems, as found in usual construction. When, however, the restraining action of the floors is absent, as when in a heavy timber building the floors fall, the excess of expansion of the inside of the wall soon curls the wall outward at the top and causes it to fall. I estimate that a temperature difference of 1000° F. between the faces of a 12 in. brick wall 20 ft. high, restrained at top and bottom, will warp it so that the center of load will pass outside of the center third; that is, the wall will become unstable.

Silica and Limestone.

The expansion of silica is of special interest, as this material enters so largely into the composition of many concrete aggregates. Quartz, a common form of silica, is a hexagonal crystal which expands much more perpendicularly to the axes of the crystal than along the axis. The axial expansion is 4.4 parts per million and across the crystal 7.4 parts per million per degree Fahrenheit. This results in severe internal stresses, tending to disrupt siliceous concrete. Also at about 1000° F., quartz undergoes a change of crystalline structure, resulting in a sudden large increase in volume equivalent to the

U. S. Bureau of Standards

The left-hand picture shows the walls beginning to lean outward due to the effect of heating and expansion of interior surface. The picture at the right, taken 15 minutes later, shows the left-hand wall fallen.

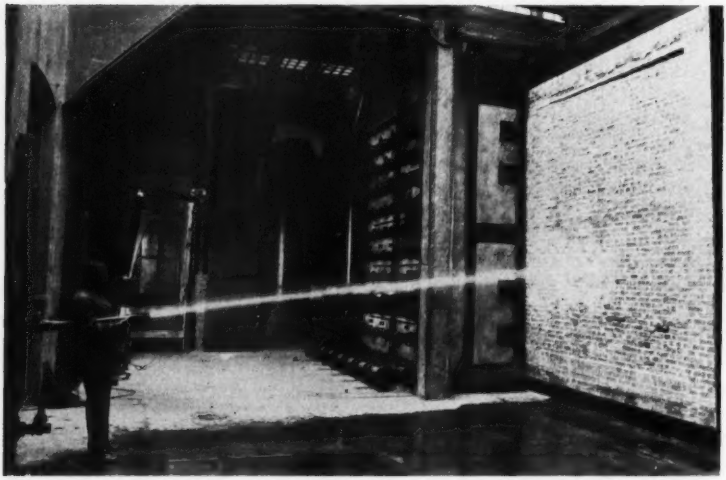
average expansion due to heating through about 300° F. Chalcedony, another common form of silica, often present in aggregates, shows a similar sudden expansion at 410° F., which results in a volume change equivalent to heating through nearly 1800° F. These peculiarities of silica render siliceous concretes as well as siliceous stones, such as granite, standstone, etc., very unsatisfactory for use in fireproofing.

Fortunately limestone is plentiful in most parts of the country and is free from these defects. Also limestone has the advantage that when heated carbon dioxide is given off and a large amount of heat absorbed in the process. Unfortunately, as Mr. Hull* points out, this reaction occurs only at a high temperature; about 1630° F., but even so limestone concretes are known to make very effective fireproofing coverings.

Gypsum.

Gypsum is an interesting element of construction. It consists of calcium sulphate chemically combined with water, so that in pure dry gypsum there is 21% by weight of water. If we heat a pound of dry limestone to 1000° F. over the initial temperature about 200 B.T.U.'s would be required. To heat a pound of gypsum would require about the same amount of heat if it were not that after passing through a temperature a little above the boiling point of water we must evaporate this combined water. This evaporation alone required over 200 B.T.U.'s beside the heat necessary to raise the temperature

*Technologic Papers of the U. S. Bureau of Standards, No. 130, p. 27.



Underwriters' Laboratories

The standard fire and water test. Projecting a hose stream on to a heated panel just removed from the test furnace.

of the material. As stated before, the absorption of incoming heat is just as important as the thermal insulating value and as a consequence gypsum performs two equally important functions in fireproofing; first, in excluding the heat to a large degree, and second, in absorbing the heat that enters. Due to the loss of water, gypsum expands only up to 212°, after which it contracts and loses much of its strength. This material has always given excellent results in fireproofing, but has been looked upon with disfavor by some because it is washed down by the application of hose streams after a severe fire test. This is in spite of the fact that a 2 in. gypsum ceiling will resist a four-hour fire without reaching more than 350° on the unexposed surface and is, therefore, an almost ideal fire retardant.

Fire and Water Tests.

The question of water testing is of considerable importance. It is quite true that it would be very desirable to have a fire-resistive construction so perfect that after a severe fire followed by application of water the construction would be ready for use again. Experience teaches that this is not possible if we must use materials and methods cheap enough to be of practical use. Every fire-resistive construction we know suffers extensive damage from severe fires. Gypsum is calcined, tile and concrete blocks are cracked, concrete and brick spall to a greater or less extent and all are often greatly damaged by expansion. The important point is the cost of making repairs. I do not believe that we can properly consider the possibility of a structure being required to resist a second severe fire after having been exposed to one fire

and then thoroughly wet down. This might occur in a warehouse containing a very large quantity of combustible material under some unusual conditions, but it seems a mistake to burden every building with a great expense to provide against such an unusual condition which could apply only to a very small number of buildings.

In repairing the underside of a floor it is much cheaper to renew a gypsum ceiling than to patch spalled concrete or tile construction. If the ceiling performs its function until the fire is extinguished the owner should consider himself lucky to escape with so slight an expense as replacing the ceiling.

The Mistakes of Building Codes.

Building code requirements have a very extensive influence upon construction in all of our large cities where the bulk of fire-resistive buildings are erected. Many American building codes have been prepared largely by copying the mistakes of others. The foundations of our fire-resistive requirements are a mixture of data derived from partial tests and preconceived ideas many of which are unfortunately erroneous. We like to talk about buildings fire-resistive for four-hour fires, whereas we rarely, if ever, have a four-hour fire, and we have very few, if any, types of construction actually resistant to a general fire of this duration. True, we have many elements of construction which will resist a four-hour fire, but when assembled in a building of commercial size and exposed to such a fire, expansion and differential expansion will soon wreck the building, although the individual elements might safely withstand the fire.

Even many of the usually accepted elements of construction are not really safe for a four-hour fire. Take columns, the subject on which we have the most complete knowledge and also the most fundamental in so far as the stability of the structure is concerned. The U. S. Bureau of Standards has shown by fire tests that steel columns protected with 2 in. of siliceous concrete are safe for only about two hours, although most codes accept 2 in. of this protection where four-hour resistance is required.* With 2 to 4 inches of hollow tile the resistance was from one hour to two hours with only a few tests exceeding three hours, although 2 or 3 inches are accepted by nearly all codes.

In regard to floors it appears that most of the types of construction now in use have either never been tested at all or have been tested with only partially satisfactory results, if temperatures of top slabs are to be considered.

Our smug and self-satisfied attitude towards fire-resistive construction is all unfounded. We insist upon the construction of buildings in accordance with certain rules with the idea that we are obtaining buildings resistive to very severe fires, whereas such buildings will *not* resist these fires. Also we are requiring these same, often expensive, methods of construction to be used in a great many buildings which cannot under any circumstances be exposed

*Technologic Papers of the U. S. Bureau of Standards, No. 184.

Board of Fire Underwriters of Allegheny County

Characteristic damage to the interior finish and fireproofing in a fire-resistive building. The structural steel was not affected and the repairs were confined to replacing the fire proofing and finish. Automatic sprinkler protection is desirable over highly combustible contents irrespective of the type of building construction.

to such severe fires. I estimate that less than 30%, on a basis of cost, of all the large buildings erected are used for purposes where large stocks of goods are accumulated, and in less than one-third of this 30% is there ever any extensive accumulation of combustible materials.

It takes a certain amount of courage to disregard precedent and strike out along new paths, but we all know that our primary object is to do away with the great life and property loss incident to the use of buildings. Mankind for centuries has patiently endured these losses and only in the past generation has any real progress been made toward bettering the condition. The pioneers deserve the greatest credit for what has been done, but like all enthusiasts in a good cause have often endeavored to obtain perfection where perfection is unobtainable. The consequence of this is always to retard the improvement rather than help it. The cost of fire-resistive building construction has often been made considerably greater than actually necessary, with the result that political expediency has dictated that non-fire-resistive buildings should be permitted for purposes for which they are certainly unsuited in view of the possibilities of economical fire-resistive construction at the present time.

Should we not admit that testing fire-resistive construction for light occupancies should be considered entirely separately from testing for heavy occupancies? I would suggest that testing for definite periods be abandoned at least for light occupancies and be replaced with tests by complete burn-out of specified weights of combustible contents.

Should we not admit that our idea that fire-resistive buildings containing large accumulations of combustible material can resist complete burn-out of contents is not well founded and that it is not safe to assume that such buildings will endure an unrestrained fire? Admitting this, we should logically limit the height of such buildings and make automatic fire protection systems obligatory in spite of the fire-resistive construction.

And lastly, would it not be wise to encourage the construction of fire-resistive buildings adequate for light occupancies, where most of our life loss is sustained, by making our requirements as liberal as possible and at the same time take a more courageous attitude toward the construction of such buildings in which the elements of construction themselves furnish fuel sufficient to produce a disastrous fire?

I firmly believe that we must proceed along some such paths as these if our children are to live securely in buildings which can be economically justified.

Firemen's Short Extension Courses.

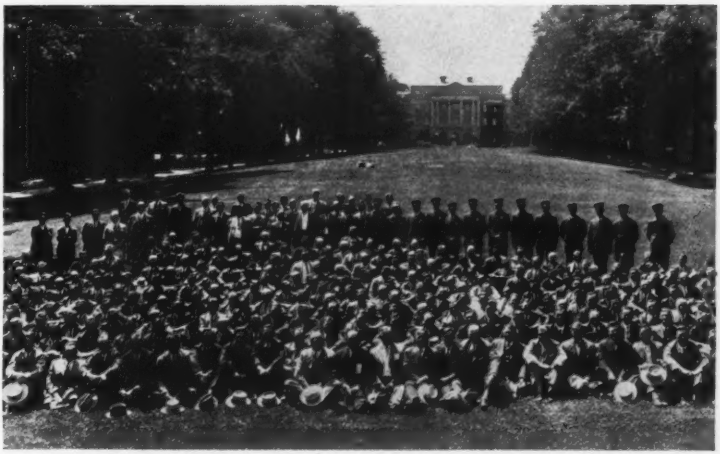
By Clarence Goldsmith,*
(Member N.F.P.A.).

The calling of a fireman has developed into a profession due to the innumerable hazardous materials and processes which have come into use since the World War and to the advent of motor fire apparatus. The fireman of yesterday does not fit into the scheme of things today any more than the old fire station, which was a stable, the steam fire engine or other horse-drawn equipment. At the dawn of this new era Chief John Kenlon of the New York Fire Department established a fire college course for the members of his department. This college was attended by many fire department officers of other cities, and other departmental schools of a more or less similar nature were established in a few of the larger cities.

Neither the financial facilities nor the talent to conduct such courses of instruction are available in the smaller cities, towns and villages. This fact was realized by those who had been engaged for a number of years in planning extension courses in our colleges, and in 1925 the Iowa State College at Ames, Iowa, and the University of Illinois at Urbana, Illinois, conceived the idea of conducting short courses for firemen. The value of these courses was immediately established, and each of these colleges has conducted short courses for firemen during each succeeding year. The results of these first schools became known in other sections of the country, and similar schools have been organized from year to year in other states. During the year 1930 such courses or schools were held in twenty states.

Toward the close of the year 1928 it became apparent to the National Fire Waste Council, which is affiliated with the Insurance Department of the Chamber of Commerce of the United States, that greater success could be obtained if these schools were properly sponsored by substantial state organizations. Fire chiefs' conventions and firemen's musters savored in the public eye as a lark and boisterous good time for those attending. The expenses of going to such meetings had, for the most part, been paid by the firemen themselves, and it was very difficult, therefore, to persuade city officials that they were justified in defraying the expenses of firemen attending the modern short courses. These established prejudices were hard to overcome, but they are being gradually surmounted through the activities of the Fire Service Extension Committee of the National Fire Waste Council, which has organized a number of state committees formed of prominent national and state officials, including the state fire marshal, and newspaper editors. These state

*Assistant Chief Engineer, National Board of Fire Underwriters; Chairman, Fire Service Extension Committee, National Fire Waste Council.



First Annual Course in Firemanship, University of Wisconsin, 1929.

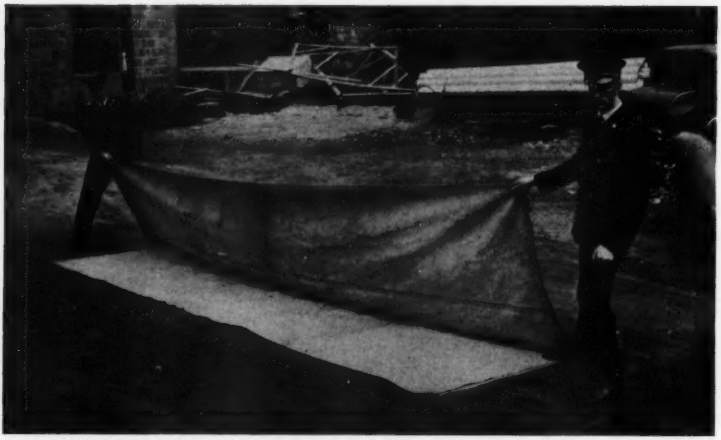
committees exert their influence through the local Chambers of Commerce and city officials in order that provisions may be made for defraying legitimate expenses in connection with the schools. The legislature of at least one state has passed an act authorizing incorporated communities to defray the expenses of such firemen as may be delegated to attend the schools, provided they submit a certificate of attendance signed by the director of the school.

In order to facilitate the operation of existing schools and to assist in the organization of new state schools, the National Committee prepared an outline for firemen's short courses, as follows:

A. Organization.

1. Director
   a. Dean of Engineering School
2. Chief Instructors*
   a. National Fire Waste Council
   b. Inspection Bureaus
   c. The National Board of Fire Underwriters
   d. Territorial Fire Insurance Organizations
   e. School Faculties
   f. Fire Chiefs or Drill Masters
   g. Safety Councils
   h. Public Utilities
   i. American Red Cross
   j. U. S. Bureau of Mines
   k. U. S. Department of Agriculture
   l. Miscellaneous
3. Committee on Course of Instruction
   a. University Officials
   b. Fire Chiefs or Drill Masters
   c. Chief Engineer of Inspection Bureau
4. Departmental Instructors (See Chief Instructors)

*These classifications from which chief instructors are drawn all include N.F.P.A. members, and in the various courses referred to in this article many N.F.P.A. members have played prominent parts.—Ed.



Instructions include salvage methods. This picture shows one step in folding salvage covers.

B. Sessions.
- 1. Time
  - a. Spring, Summer or Early Fall
- 2. Place
  - a. University City
  - a. Large City
- 3. Length
  - a. From Two to Six Days

C. Objects.
- 1. Standardization of Methods
  - a. Fire Prevention
  - b. Fire Control
  - c. Salvage
  - d. Life Safety

D. Proposed Subjects.
- 1. Fire Prevention
  - a. Protection of Existing Business Districts
  - b. Hazards, Common and Special
  - c. Citizens' Responsibility
  - d. Chemistry of Fire
  - e. Fire Department Fire Prevention
  - f. Explosives, Including Dust Explosion Hazards
  - g. Electric Hazards
  - h. Laws on Fire Prevention
    1. Municipal; 2. State
  - i. Building Inspections
  - j. Standard Fire Escapes and Exits
  - k. Building Codes
- 2. Fire Control
  - a. Practical Training for Firemen
  - b. Construction, Operation and Maintenance of Automotive Equipment.
  - c. Advances in Fire-fighting Methods.
  - d. Chemistry of Fire
  - e. Arson
  - f. Fire Streams
  - g. Chemical Extinguishers and Other First Aid Appliances
  - h. Problems of Volunteer Departments

i. Sprinkler Systems
j. Ventilation
k. Drill Evolutions
   1. Ladder
   2. Pumper
   3. Hose
   4. Rope
   5. Rescue
   6. First Aid
   7. Salvage
l. Gas Masks and Inhalators
m. Alarm Systems
n. Fire Department Discipline
o. Fire Department Administration
p. Private Fire Equipment and Its Utilization
q. Hydraulics
r. Legal Rights of a Fireman
   1. State
   2. Municipal
s. Laws on Fire Control
   1. State
   2. Municipal
t. National Board Standards
   1. Apparatus
   2. Equipment
      aa. Hose Wagon
      bb. Truck
      cc. Pumper
      dd. Chemical Wagon
u. Overhauling
v. Organization and Problems of Rural Fire Departments
w. Farm Fires

3. Salvage
   a. Covers
   b. Methods
      1. Covering
      2. Bagging
      3. Spouting
      4. Overhauling
      5. Temporary Repairs
4. Life Safety
   a. First Aid
   b. Life Saving
   c. Resuscitation
   d. Fire Exit Drills
   e. Fire Escapes and Exits
   f. Psychology of Panics

E. Honors.
   1. Certificate Issued by University
   2. Badge of Merit

Up to this time it had been observed that the method of organization and operation of the schools had not been uniform in the several states where they had already been conducted. Inasmuch as they had been successful individually, it appeared that the type of organization was not a criterion of their efficiency, and, although it seemed undesirable to endeavor to formulate any set standards, the committee prepared a tentative program for conducting a three-day school. (See diagram.)

The number in attendance at most of the schools was so great, being

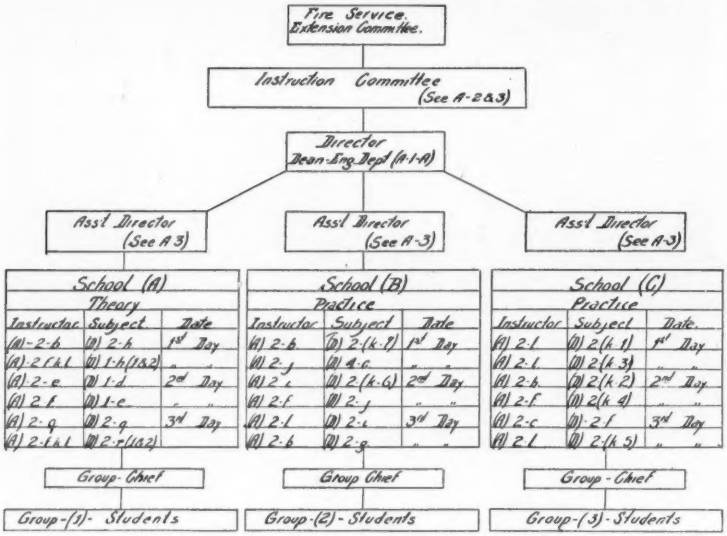


Diagram of Typical Schedule for Three-Day Course.

from two hundred to fifteen hundred, that it was impracticable to give the instructions to all of those in attendance in one group, so a scheme to provide a rotating program was developed, as follows:

8:00 A.M. Registration and Assignment of Groups under Group Chiefs.

9:30 A.M. The Short Course—By Director.

10:00 A.M. Group (1) School (A)
Topics and Instructors Selected by Instruction Committee.

10:00 A.M. Group (2) School (B)
Topics and Instructors Selected by Instruction Committee.

10:00 A.M. Group (3) School (C)
Topics and Instructors Selected by Instruction Committee.

1:30 P.M. Group (2) School (A)
Program same as Group (1) School (A) at 10 A.M.

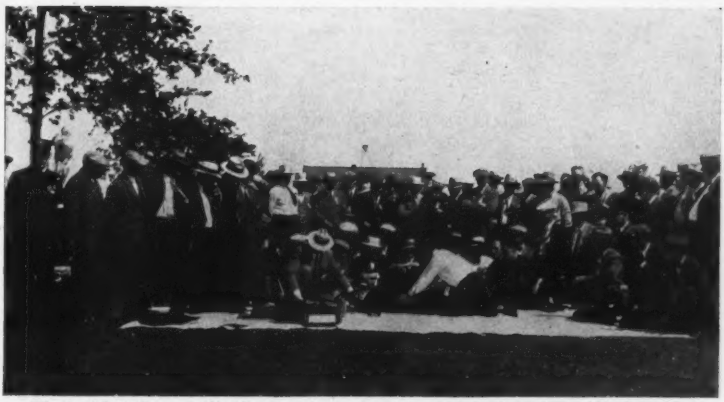
1:30 P.M. Group (3) School (B)
Program same as Group (2) School (B) at 10 A.M.

1:30 P.M. Group (1) School (C)
Program same as Group (3) School (C) at 10 A.M.

3:30 P.M. Group (3) School (A)
Program same as Group (1) School (A) at 10 A.M.

3:30 P.M. Group (1) School (B)
Program same as Group (2) School (B) at 10 A.M.

3:30 P.M. Group (2) School (C)
Program same as Group (3) School (C) at 10 A.M.



First aid and resuscitation are important features of modern fire fighting.

Suggested Grading Schedule.

Participation	30%
Interest	25%
Attendance	20%
Notebook	15%
Punctuality	10%

The foregoing suggestions have served as a guide to committees who have been charged with preparing the programs. These committees in general are made up of representatives of state firemen's associations, one or two members of the faculty of the educational institution sponsoring the course, and several of the men who have served as instructors in the previous schools.

When the programs have been prepared, they are sent out either from the office of the state fire marshal or by the state firemen's associations to the official head of the fire department in each community. In states which have municipal leagues, the secretary of this organization circularizes the members.

In attempting to formulate a curriculum of instruction on almost any other subject, advantage may be taken of a vast amount of published data available, but unfortunately little, if any, usable material in connection with the subject of fire-fighting has been collected and published in proper form. An investigation shows that such publications, exclusive of firemen's magazines, do not exceed twelve in number.

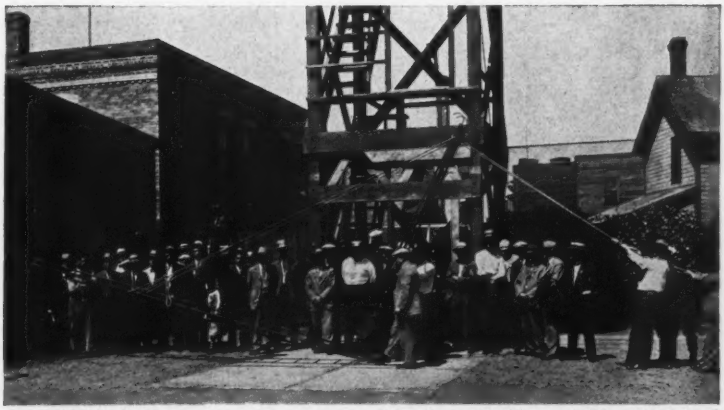
The International Association of Fire Chiefs, at its annual convention in 1929, unanimously endorsed an educational program and has been engaged since that time in the preparation of texts covering most of the subjects which should be included in the complete course. A few of these texts have been published and others will be published as fast as funds are made available. Chief Ralph Scott of Los Angeles, then president of the association, through his personal efforts, later in that year carried out a very compre-

hensive program of instruction in schools which covered the Pacific Coast. He realized the value of visual education, and had made, under his direction, a sound film depicting the problems of building inspection. During the present year he directed the making of a second sound picture, entitled "The Salvage Man," which was sponsored by the National Board of Fire Underwriters.

The schools which have been conducted during the past year have benefited from previous experience. The earlier schools, which were in fact an outgrowth of the so-called conventions, had programs made up almost entirely of lectures and addresses. It is manifest that the desired benefits cannot be derived from a program of this nature, for not even a young college student could attend a series of lectures extending throughout the entire day and properly absorb the instructions. Educators agree that lectures have proved to be the least effective method of reaching the pupil, and, in any case, they should not last for over thirty minutes. Instruction can be passed to the pupil much more advantageously by a round-table method, which should be adopted for the last half of the period assigned to the subject. Motion pictures, either silent or sound, appear to have some advantages over the lecture method, particularly on certain subjects. Lectures with actual demonstrations, such as may be performed in a chemical laboratory lecture room on the subject of "Chemistry of Fire," are productive of excellent results. The actual participation of the student, however, is the best of all methods and should be utilized in connection with the subjects of "Drills and Training," "First Aid," and the like. In order that those in attendance can take part wholeheartedly, all firemen should be notified to bring their working turn-outs to the school.

Hose and ladder drill at the Michigan Short Course, 1929. Learning the proper way to carry a hose line to an upper story over a ladder.

The question of financing the schools themselves has been given considerable thought, for the conduct of a school, including the expenses of printing and stationery, together with other incidental expenses, costs several hundred dollars. In some states it has been possible to have the legislature make



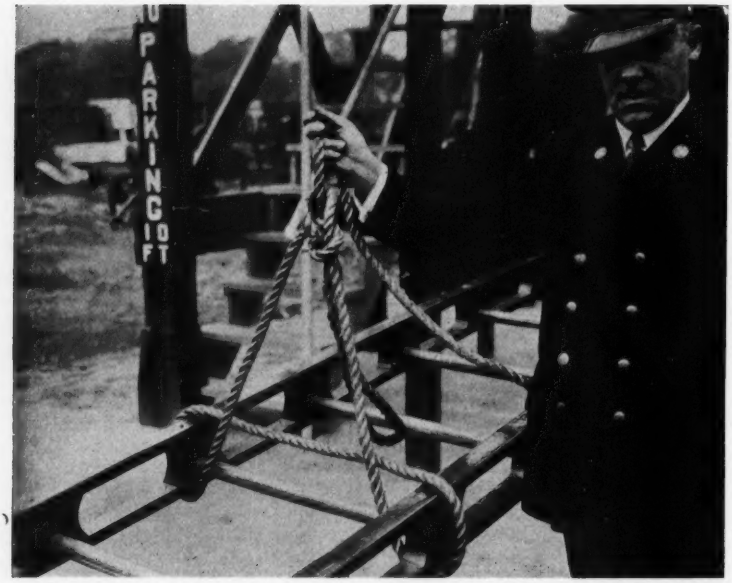
Bridging ladders. An emergency operation for extending a ladder from roof to roof across an alley or from a roof to a window opposite.

annual appropriations for the school. In other states funds have been made available from the extension course allotments of the universities, and fire marshals' offices have, in many instances, substantially contributed. Several of the states have published the proceedings of their annual schools and the expense of these documents has been defrayed to a large extent by the advertising material contained in the publication. Liberal contributions have also been made by coöperating bodies, and a fee is charged for copies of the proceedings when requested by those who were not in attendance at the schools. At several of the schools registration fees have been assessed in order to comply with the state laws which govern the universities.

In order that a school may attain its full measure of success, a drill tower should be available. One state university constructed a tower from funds specifically allotted for this purpose. Many of the schools have been held in cities where the fire department has already been equipped with a drill tower.

Most of the schools keep an attendance and efficiency record of the students, basing the latter upon the notes taken during the course. Certificates are issued each year, and diplomas are issued to men who have attended three consecutive courses.

The benefits derived from the school are many. First, and most important, it teaches the fireman the most efficient way to perform his work. Second, and almost equally important, is that with the knowledge gained from the short courses, the fireman is going to be more insistent that enlistment and promotion be based on sound civil service practices, which will assure the best qualified men securing appointment and promotion, and also render their tenure of office secure. In order that the results of these schools may



Every fireman should know how to tie the standard knots. This picture shows a bowline properly fastened to a ladder.

attain their fullest possibility, those in attendance should not only concentrate on the work in hand, but should disseminate all the information they obtain among their co-workers when they return to their own departments.

In the states where schools have been held for a number of years the major portion of the instructing faculty may be selected from members of the fire departments in those states. In states where new schools are organized it is found that fewer fire department members have had an opportunity to develop themselves to give instruction.

Those connected with the work are confident that it is but in its infancy. The schools which have already been conducted have selected the subjects to be taught, first, on account of their general interest, and, second, because instructors were available to teach them. The time has now arrived for formulating a curriculum which will take up the subjects in a logical order in the same manner that other engineering courses are planned. Provision should also be made to continue advanced instruction to those who attend the schools year after year, in the same manner as colleges carry on post-graduate courses. The Oklahoma Firemen's Training School is now developing an educational program under the supervision of its director, with the collaboration of the Director of Vocational Education of the Oklahoma Agricultural and Mechanical College, which contemplates progressive instruction extending over a

period of several years. It is planned to have the representatives of the cities participating meet at some central point four times a year to discuss the texts which will be submitted for use during the succeeding periods of instruction. The representatives, after attending, will return to their own cities and carry out the program of instruction in detail.

Instruction in the State of New York has been carried on along lines similar to those proposed for this use in the State of Oklahoma for the past two years. The training facilities are provided under the direction of the New York State Conference of Mayors and the New York State Fire Chiefs' Association. The state is divided into eighteen zones in which sixteen regional schools were conducted during the present year and where over three thousand firemen from eighty-one municipalities attended.

The credit for the establishment and continuance of these short courses for firemen is due to the firemen themselves, as they have realized the need of further education and have spontaneously demanded and secured the means to get it. The original idea of short courses for firemen had its inception in the central part of the United States, where it gained impetus and spread through to the major portion of the northern states lying between the Rocky Mountains and the Allegheny Mountains, and swept over and embraced the Pacific Coast. Several of the southern states have followed the lead of the northern states, but there has been a marked apathy in the establishment of short courses for firemen in the eastern states along the Atlantic seaboard and westward to the Allegheny Mountains, except in New York State.

All who are interested in fire prevention, who have not done so, should support the establishment and operation of the schools so that instruction may be available to all firemen in the United States. The growth during the past year has been very gratifying. In 1929 twelve schools were held, and in 1930 schools were held in twenty states, and nine thousand three hundred and forty-nine firemen were registered in attendance.

Private Fire Brigade Organization.

Pittsburgh Plate Glass Co.

By J. S. Dodge (Member N.F.P.A.) and H. J. Hartmann,
Pittsburgh Plate Glass Co.

The manufacturing organization of the Pittsburgh Plate Glass Company consists of nineteen separate manufacturing units. These units consist of five large plate glass plants, producing nothing but plate glass; three window glass plants manufacturing window glass; five paint plants handling all products of paint industry, such as dry colors, lacquers, oil and lead paints; a linseed oil plant; a cement plant; a chemical plant producing calcium chloride, soda ash, fertilizer, caustic soda, etc.; a paint brush plant; a brush handle plant which is exclusively a woodworking establishment; and a refractories plant. Practically all of these plants are in isolated locations where public fire protection is out of the question.

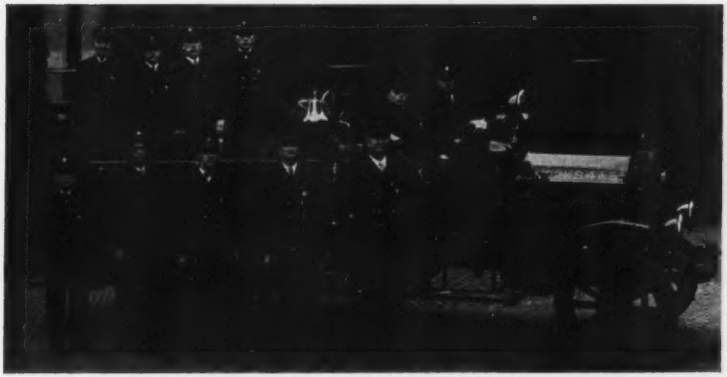
We were naturally very much interested in eliminating fire hazards at each plant, and realized that to accomplish the end in view it was essential to establish a regular and thorough system of inspection. We also wanted to have an efficient fire brigade able to judge intelligently the nature of a fire and the manner in which it should be fought to keep the fire and water loss down to a minimum. This last item is very important on account of the nature of most of our products, and especially true in our glass factories.

With this in mind we adopted an educational program in the early part of 1926, and at that time definitely decided that fire prevention was to be considered as an operating proposition. We organized an inspection service to eliminate as far as possible the causes of fire and a fire brigade to handle a fire should one occur. It was necessary to have a trained man at each plant who would exact rigid fire prevention measures and who could organize a fire brigade. We realized that the fire chief of each organization must not only be efficient in the handling of his men, but should also be capable of combating the fire hazards characteristic of his particular plant. Such men are not easily located.

Fortunately, at one of our plants we had a full time fire department. The chief of this department, a graduate of the New York Officers' Fire School, is experienced in the handling and training of men and maintains a well-drilled fire brigade. We thus had at hand a training school where we could send

---

The experience of the Pittsburgh Plate Glass Company with its organization for fire prevention and extinguishment is a typical example of modern industrial plant methods. This is of particular interest because, owing to the wide variety of the plants covered in this program, the methods employed are not limited to special plant conditions, but are of a general character, applicable to a wide variety of industrial plants.—Ed.



The full time plant fire department.

representatives from our various plants, and as many of our fire chiefs were not familiar with the numerous duties involved in fire prevention work, we decided to give each of them a two weeks' training period at the school.

Each new candidate during this period is not only instructed in organizing and handling a private fire brigade, but is also educated in the methods of properly taking care of all types of fire equipment. He participates in all the daily drills, which includes a drill with the fire truck.

During the evenings the recruit is trained in methods of tying knots and their uses, such as axe hitch, chemical hitch, pike pole hitch, ladder hitches to hoist short and long ladders to roofs. He is also instructed in first aid methods of resuscitation, emergency dressing of injuries and what to do in case of an accident. Artificial respiration and the use of the inhalator is an important part of this educational program, so that every member of our fire brigade may know what to do in case a person is overcome by shock, drowning, suffocation, etc.

The most important part of this training is the daily inspection work. This includes the examining and testing of all fire extinguishers, fire doors, outside hose houses, hydrants, sprinkler systems, all valves pertaining to fire protection, fire and sprinkler alarm boxes, etc. The inspection work comprises two trips for each platoon—one inspection covering sprinkler systems, fire extinguishers, and general housekeeping conditions throughout the entire plant; the other dealing with the testing of all fire doors and the examination of hydrants and valves. Each recruit makes both inspection trips daily, each of which is in itself a real fire prevention education.

By following this training method we have succeeded in obtaining a well-trained private fire brigade at practically all of our plants. Regular and thorough inspections familiarize the chief with the hazards peculiar to his

particular plant and materially aid in avoiding unnecessary loss and danger. We believe that with the maintenance of constant inspection with proper reports, together with a first class fire brigade, the probabilities of a serious fire occurring in our plants are remote.

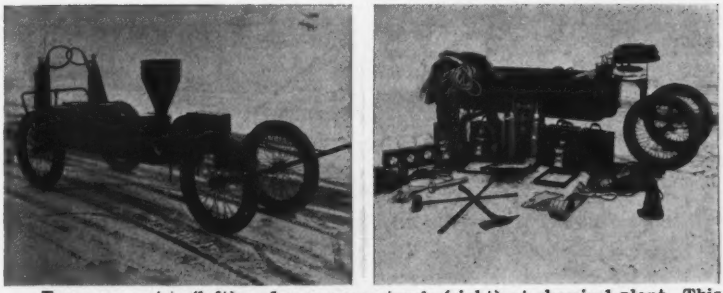
Poor housekeeping, obstructed fire equipment, and special fire hazards are reported to the head of the department where the trouble is located after each inspection trip. These reports are in writing and a carbon copy is retained by the inspector to be checked again at the next inspection. We have found that it is a material aid to the plant management to periodically look the inspection book over and see what the inspector has been doing. The manager is expected to initial the book at this time, and the records will indicate to the insurance department the amount of supervision given to fire protection at his plant.

A monthly report to the General Office is required from the fire chief of each plant, showing the number of fire drills held each month and also a monthly fire equipment inspection report. If a fire, serious or otherwise, occurs, the particulars are immediately reported to the General Office, and if necessary a thorough investigation is made by a representative of this office. This enables us to keep a complete statistical record of fires throughout our entire organization.

Of course, having so many different types of industries, each plant has its own particular fire prevention problems, and it is solely up to the chief to make proper arrangements to combat them. The equipment used by our chemical plant is an example of meeting a local plant condition. It has proved to be invaluable to them. The chief of this particular plant, after being educated at our fire school, organized and trained a volunteer fire brigade. This particular plant is very large and has many fire and accident problems which necessitate the quick transportation of equipment to care for a wide variety of emergencies. His ingenuity has developed many special aids to meet his particular needs.

One piece of this special equipment is known as the plant emergency truck and carries a variety of equipment, such as gas masks, jacks, sledges, ropes, inhalator, electric lanterns, acetylene cutting torch, bandages, blankets, bars, life belts, extension cords, axes, rubber gloves and rubber coats. The other carries a portable foam generator. It also carries several lengths of standard fire hose, a supply of foam powder, several shut-off nozzles, sprinkler heads and two carbon dioxide extinguishers.

These trucks are about three feet wide, having a wheel base of about six feet, and are mounted on regular Ford wheels, with roller bearings and balloon tires. They are so designed that they can enter any doorway and easily pass through the congested areas in this plant. The trucks can be handled easily by one or two men, and both pieces of equipment respond to a



Foam generator (left) and emergency truck (right) at chemical plant. This equipment may be handled by one or two men and can easily pass through the doorways and congested area of the plant.

signal from any of the plant fire alarm boxes. The emergency truck has already proved its value in several instances at this particular plant.

In addition to the inspection program we have recently compiled an extensive fire prevention and safety inspection program to be used by all the foremen in our various operations. This program is strictly an educational campaign which we feel should aid our foremen in properly maintaining the physical properties under their jurisdiction. We feel that this program will not only educate the foremen along fire prevention and safety measures, but will enable each of them to eliminate unsafe conditions likely to be found in his department.

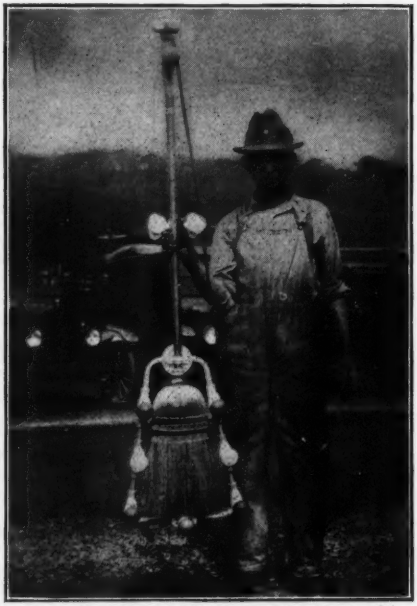
We have arranged this program in the form of fire and safety suggestions and expect each foreman to familiarize himself with all the items. He can serve as his own inspector or delegate someone in his department to see that all the items mentioned are given minute consideration. These suggestions intelligently applied by the foreman should practically eliminate a number of fire and safety hazards and aid in further improving housekeeping and general maintenance.

The inspection service is also a valuable asset to our safety program. The fire inspector is educated to note all unsafe conditions, such as boards lying around with nails in them, unguarded gears, improperly piled materials, broken steps in stairways, or any other unsafe conditions observed on his trip. All conditions of this nature are reported to the safety engineer at the plant. Poor housekeeping and many fire hazards are preventable through rigid fire and safety inspections.

Housekeeping receives constant attention in all the plants and in many cases has been producing startling results. Regular contests are carried on in practically all of the plants, and much interest is taken in maintaining clean and orderly departments. The departments are inspected and rated by the fire chief, and the best department is permitted to display during the following

month a large broom mounted in a frame of colored electric lights. A regular system of merits and demerits is used for equipment and tools out of place as well as dirt or an untidy working area.

The success of such a program depends largely upon educating every individual from the highest executive to the common laborer, and upon their hearty coöperation. We emphasized the fact that many preventable causes of shut downs, loss of time, and personal injuries were due to indifference or carelessness, the reverse of which would be profitable to all concerned.



The department judged by the fire chief to have the best housekeeping during the preceding month displays this illuminated broom.

In addition to this educational program and building up a fire brigade and inspection service at each plant, the Insurance Department is consulted on all matters pertaining to fire protection regardless of whether it concerns new construction or simply making a minor improvement at one of the plants. In other words, everything pertaining to fire protection is handled through the Insurance Department at the General Office. The organization was expanded rapidly and contains so many diversified industries that fire prevention has become a business by itself which demands constant attention.

Another factor which has proved invaluable towards unifying our fire prevention work is the Annual Safety and Insurance Conference. This is a three-day conference and is held at a different plant each year. This conference is attended by representatives from each of our various plants and deals strictly with our own fire and safety problems. One evening session is devoted to community fire protection and safety, and representatives of neighboring industries are invited to attend and participate. The object of meeting from plant to plant is to increase the effectiveness of our fire and safety program through free and full discussion of each plant's problems and planning to strengthen the program for the next year.

Our program has proved very effective, as indicated by the results obtained. During the year 1925 there were reported a total of nineteen fires with an estimated loss of $5500. In 1927 there were thirteen fires reported with a total loss of approximately $500. During 1929 there were twenty-three fires reported with an estimated loss of $800. We were undertaking very extensive reconstruction operations in 1929 and nineteen of these fires were the direct result of these operations. Housekeeping and general maintenance conditions in our plants are very good and will pass rigid inspection at any time. All the equipment pertaining to fire protection in our plants is regularly inspected and ready for immediate use at all times. Our various brigades have proved their value not only in actual fire fighting but also in the daily work of preventing fires and eliminating hazards throughout the entire organization.

Experience and Discovery

Over northern America are strange ridges of gravel, boulders far from home, and curious scratches on the rocks. How did they occur? Did a comet "side-swipe" the earth? Agassiz, who had observed Alpine glaciers, noticed similarities between these formations, and similar phenomena about existing glaciers; and the theory of a great glacial period occurred to him. Would the theory have been born without existing glaciers to suggest it?

In Yellowstone Park, algae, diatoms, and other primitive plants thrive in hot springs almost at the boiling point. They suggest that perhaps we must look to the peculiar conditions existing at the boiling point of water, and not at ordinary present terrestrial temperatures, for the origin of life. Because of the regulating effect of the great latent heat of steam, the earth's surface probably remained almost exactly at the boiling point for millions of years.

It is through actual experiences that nearly all ideas and theories originate.

—*Antioch Notes.*

Norwegian Royal Residence Fire.

Reported by Norsk Brandvern Forening,
(Norwegian Fire Protection Association, Member N.F.P.A.).

In the vicinity of Oslo, at a distance of about twelve miles from the city, stood the residence of the Norwegian Crown Prince Olaf. The house was an old mansion of frame construction and tile roof, which formerly belonged to the Norwegian Minister in Paris, Wedel-Jarlsberg. When Crown Prince Olaf married the Swedish Princess Martha in 1929 the question arose as to a residence for the royal couple. Minister Wedel-Jarlsberg thereupon presented to them the whole of his estate at Skougum with all its valuable furniture, paintings, table service and tapestries.

On the 20th of May, 1930, an outbreak of fire was discovered in the attic of the main building, apparently due to a defective flue. Dense smoke and heat hindered the work of extinguishing the fire, and with only chemical extinguishers and hand engines immediately available the flames spread rapidly through the upper portion of the structure. By the time the local fire brigade arrived with its motor pump* and the Oslo fire brigade reached the scene with its automobile pumpers the fire had gained such a grip on the old wooden building that little could be done to save it. The mansion was completely destroyed.

There had been time, however, to rescue the most valuable of its contents. A large quantity of valuables, including wedding gifts that the royal couple had received, were carried down during the early stages of the fire to a fire-resistive vault in the basement. This vault afforded complete protection against the flames, for when it was opened after the fire its contents were found intact and undamaged.

The vault, which was located in about the middle of the basement, had been fitted up about six months previous to the fire, but had not been put into actual use until a few days before the fire occurred. Two of its walls were formed by the existing foundation walls, built of rubble stone and respectively 29½ and 39 inches thick. The two other walls were of brick, constructed as double walls each approximately 10 inches thick with a 2-inch air space between. The vault roof was formed of two layers of reinforced concrete, each 6 inches thick, and between these was cork 3 inches in thickness. The

*In European countries a "motor pump" is a gasoline motor-driven pump of small capacity mounted on two wheels and used as a trailer or drawn by hand. Pumpers similar to the motor pumps of the United States and Canada are known as automobile pumps. —Ed.

The residence of Crown Prince Olaf of Norway at Skougum before and during the fire. Lack of fire-fighting equipment at the start allowed the fire to gain such headway that the structure was totally destroyed.

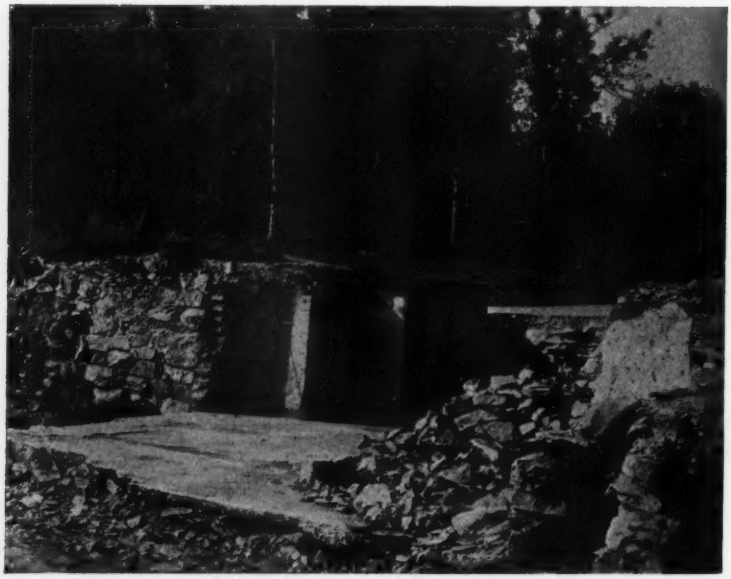
outer door of the vault was of the ordinary office-safe type 5 inches thick. The inner door was a single iron-plate door without insulation.

This vault and doors were subjected to tremendous heat as the whole building above the basement was of frame construction, which by degrees collapsed and then lay in a glowing mass over and around the vault. The surrounding temperatures may therefore well be estimated at from 1800° to 2100° F. Not until eight days after the fire had the ruins cooled sufficiently to permit the opening of the vault.*

*This vault door assembly, apparently constructed without heat insulating material, could not ordinarily be relied upon to protect combustible contents, with the exterior of the vault subjected to long-continued temperatures of 1800° F. or higher. The favorable result in this case may perhaps be explained by the fact that the vault was subjected to severe heat only on one of its six sides, heat conduction through the other sides tending to cool the contents. Or, some local cooling of the hot débris may have occurred in the vicinity of the door, due to water from fire department hose streams or other cause. Fire tests conducted at the U. S. Bureau of Standards have shown that débris temperatures are usually much lower than indicated here.—Ed.

The door of the vault showed on the outside a slight bulging at the top and on the inside the paint had been somewhat blistered by the heat that had penetrated through it. Inside the vault the heat had caused the comparatively new brickwork to sweat out a quantity of water in the form of small beads of moisture on the walls and the air was damp. The contents of the vault were intact—not even slightly damaged.

The work of erecting a new building is now in full swing. It will not be of timber, but of concrete and will therefore be completely fire-resistive.



This basement vault in the residence of Crown Prince Olaf of Norway protected its contents in spite of the complete destruction of the building. This photograph was taken after the ruins had been cleared away.

A Review of Some Recent Dust Explosions.

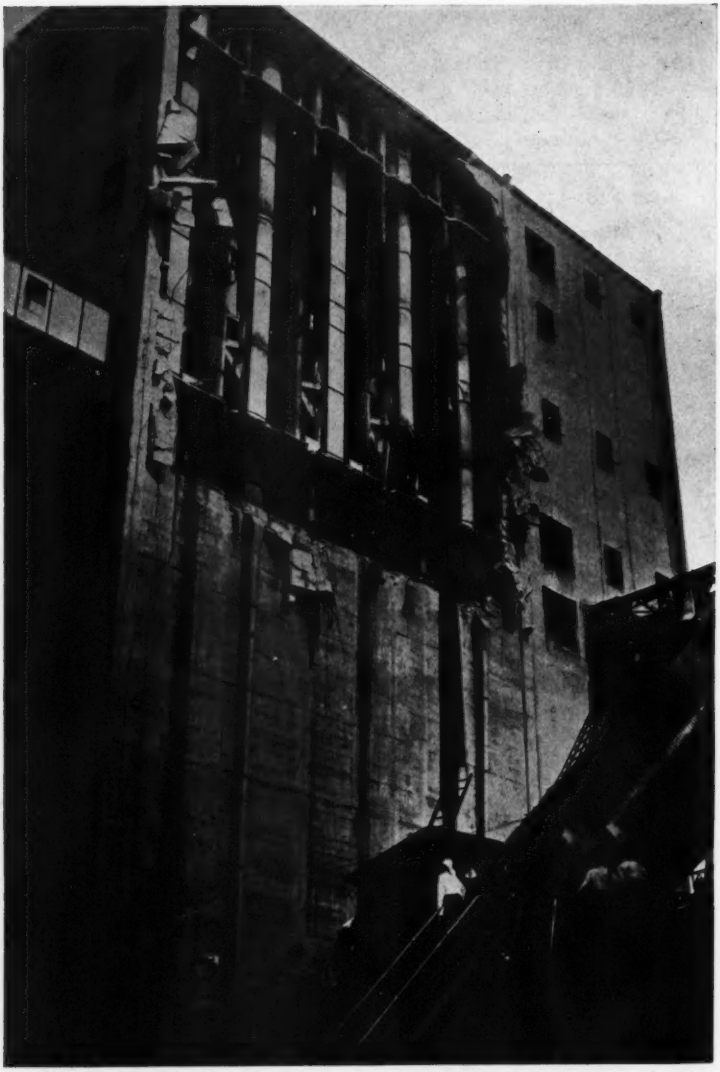
By David J. Price and Hylton R. Brown,*
N.F.P.A. Committee on Dust Explosion Hazards.

This review of recent explosions prepared by the officers of the Committee on Dust Explosion Hazards of the National Fire Protection Association furnishes convincing evidence of the importance of measures to prevent dust explosions and minimize their damage, which have been studied by the committee over an eight-year period. Through the regulations prepared by this committee, in co-operation with the industries concerned, the results of the technical research of the U. S. Department of Agriculture have been translated into actual practice. It is believed that in at least two of the explosions described on the following pages the damages have been minimized and many lives saved, owing to compliance with the recommendations of the committee, particularly in respect to the provision of adequate venting facilities and proper maintenance and general upkeep of the property.

Between the period of August 20 and September 20, 1930, a series of dust explosions occurred in industrial plants. The first occurred in the Western Maryland Grain Elevator at Baltimore, Md., on August 20, 1930, resulting in the loss of six lives, injuries to fourteen others, and property damage of approximately $250,000. This was followed by an explosion in a feed grinding plant in Kansas City, Mo., on August 22, 1930, which caused the death of two men, injury to two others, and property damage of $75,000. A third explosion in a feed grinding plant in Minneapolis, Minn., resulting in the loss of two lives and property damage of $100,000, occurred on August 26, 1930.

On September 12, 1930, an explosion of tobacco dust of minor proportions occurred in a tobacco by-products plant at Richmond, Va. On September 20, 1930, an explosion of starch dust at the Staley Manufacturing Company, Decatur, Ill., resulted in the death of six men. These explosions are reviewed in the following article.

*Mr. David J. Price (Member N.F.P.A.), Chairman of the N.F.P.A. Committee on Dust Explosion Hazards, is Principal Engineer in Charge of the Chemical Engineering Division, Bureau of Chemistry and Soils, United States Department of Agriculture. Mr. Hylton R. Brown, Secretary of the N.F.P.A. Committee on Dust Explosion Hazards, is Engineer in the Chemical Engineering Division, Bureau of Chemistry and Soils, United States Department of Agriculture. The publication of this review in the N.F.P.A. QUARTERLY has been authorized by the Department of Agriculture.



The Western Maryland Railway Company Elevator following the explosion in which six men lost their lives, fourteen were injured and property damaged to the extent of $250,000. This picture shows the extent of the damage to the workhouse walls.

Explosion in Western Maryland Railway Company Elevator.

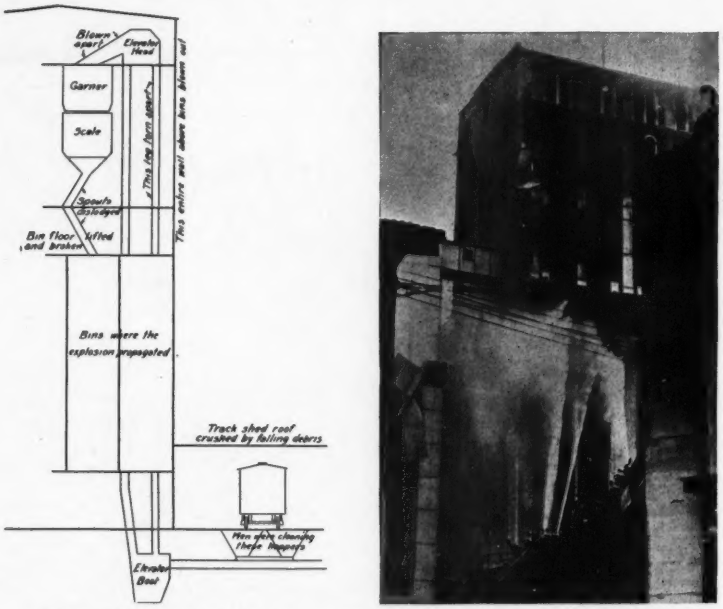
Baltimore.

A dust explosion of unusual interest occurred at 11:55 A.M. on August 20, 1930, in the export terminal grain elevator of the Western Maryland Railway Company located at Port Covington, Baltimore. Two men were killed and eighteen were injured. Four of the injured men died later in the hospital to which they had been taken immediately after the explosion. The property damage, which amounted to about $250,000, was confined to the workhouse, driers, track shed and bridges or galleries leading from the bin floor of the workhouse to the storage section of the plant. No appreciable amount of grain was damaged.

Description of Plant.

The Port Covington elevator, built in 1915 with a storage capacity of 1,000,000 bushels, was later enlarged to increase the storage capacity to approximately 4,000,000 bushels. The plant consists of a workhouse, driers, and storage section, each section being a separate structure but connected by means of tunnels and galleries. Eight lofter legs are provided in the workhouse section; two of these are receiving legs and the remaining six shipping legs. The two receiving belts serving the receiving legs run beneath the four tracks entering the track shed, which occupies the space between the workhouse and the storage section. The workhouse contains the necessary cleaning, weighing and distributing equipment generally found in a terminal or export elevator.

Perhaps the most unusual features of this plant are the dust collecting and dust removal systems. These systems supply suction for floor sweeps, belt tail hoods, receiving belt hoods, and cleaners. The dust removal system removes all the collected dust from the plant to a dust house located some distance from the other building. In addition to the two systems, mention must also be made of the efficient natural ventilation system. All storage bins have 12-inch natural vents extending through the roof and 18-inch vents have been installed on all garners. Many of the elevator legs are also vented to the outside. Numerous louvers, windows and floor gratings provide an abundance of natural ventilation. Open doors and windows and the fact that a large part of the basement is above the ground level make it exceptionally easy to ventilate the basement. James A. Peterson, the superintendent of this elevator, always has been greatly interested in dust explosion prevention and has made every effort possible to keep the plant modernized and clean. Strict rules always have been enforced to prevent smoking or the use of open flames in the elevator. Particular care has been taken to eliminate sparks or other possible sources of ignition. Dust-proof lamps have been installed and a hot-journal alarm system provides protection against fires from overheated bearings. An



Left: Diagram showing the equipment in the Western Maryland Elevator through which the dust explosion propagated.
Right: Large quantities of water were thrown into the workhouse by firemen to extinguish smoldering fires after the explosion. Fire fighting operations in a structure of this kind present unusual difficulties.

efficient system of signaling and first aid fire protection has been installed, and watchman service is maintained at all times.

Story of the Explosion.

The explosion occurred under somewhat unusual circumstances. According to reliable information at least five distinct reports were heard, which would indicate that there were at least five major explosions. It is quite evident that a series of explosions occurred, as the flames propagated from one section of the workhouse to another and ignited the various dust clouds. Just previous to the first flash the employees had completed the unloading of the grain cars received at the plant. They were engaged in cleaning the receiving pits, a practice which was followed each day as soon as unloading was completed. According to reports only two legs in the house were operating, although there is some question as to whether the other legs had completely stopped running. The two receiving legs had been kept in operation in order to carry away the dust swept down by the men cleaning the receiving pits. These two legs were discharging through their respective garners and scales

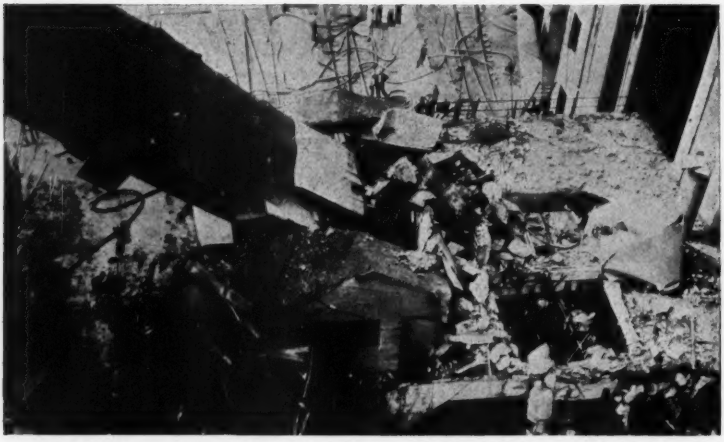
into bin No. 40, an interstice bin near the center of the workhouse. It was the custom to store elevator and car sweepings in this bin until it was possible to run the material over a separator to remove the grain.

It has been impossible to get a coherent story of the explosion from the employees or eyewitnesses outside the plant, but from the information which it has been possible to collect, the flash appeared throughout the entire workhouse at about the same time. Ordinarily it is comparatively easy to trace the path of an explosion through a plant by the marks left on the machinery or structural members. In this case the task has been complicated by the fact that more than one explosion evidently occurred at or near the same point. Employees working in or near the track shed report that a flash of fire entered the shed from the first floor of the workhouse. Others maintain that the flash came up through the receiving pits. It is quite likely that both groups are right. At first thought it would seem most logical to reason that the ignition occurred in the track pits themselves, but the evidence available indicates that the flame and pressure wave traveled from the upper floors of the workhouse down through the legs and connecting tunnels to the receiving pits. Leg casings were ruptured on the first floor, which would explain the flash which employees reported entering the track shed from the workhouse.

On the upper floors of the workhouse, where the greatest damage occurred, plenty of evidence is available to indicate the tremendous pressures created in the garners, scale hoppers, and bin No. 40 as the explosion passed from one to the other. On the top or motor floor, sections of the concrete floor, which also formed the tops of the receiving leg garners, were destroyed by the explosion, the evidence indicating that the floor had first been lifted and then dropped back into the garners. A survey of the damage on the bin floor shows that the concrete floor forming the top of bin No. 40 had been blown off, and the pressure within the bin was sufficient to rupture the wall and permit the flame to enter one of the elevator leg wells adjoining. Some damage also occurred in the drier building, where the steel bin top was bulged upward, some windows blown out, and the metal ventilating equipment in the side of the drier building destroyed.

Point of Origin of the Explosion.

From thorough consideration of the available evidence and the stories of the employees and eyewitnesses, it seems that in this explosion, or rather this series of explosions, the original flash occurred in one of the garners, scale hoppers or bin No. 40. Two receiving legs, two garners, two scale hoppers, and bin No. 40 all were interconnected by means of spouts, and a flash in one would be quickly communicated to the other. By far the largest explosion, or the one of greatest violence, occurred in bin No. 40. It is possible that the original flash may have occurred in this bin, but it is more likely that the first flash occurred in one of the garners and was communicated through the scale



Looking down from one of the galleries, showing the damage caused by the galleries and a section of the workhouse wall falling on the track shed.

hopper and spout to bin No. 40. After the explosion in the bin other explosions occurred in quick succession in the adjoining elevator leg well and the second connected scale hopper and garner.

Possible Causes of the Explosion.

No evidence has been obtained to indicate definitely the cause of the original explosion. The work in progress at the time undoubtedly created dust conditions favorable for a dust explosion. In some manner this dust was ignited, and due to the fact that an unusual amount of dust was in the air, sufficient pressure was produced to seriously damage the building and equipment. Foreign material entering the bucket elevator with the grain and dust swept from the receiving pits may have produced a spark or fire which ignited the dust cloud. Friction in the elevator itself may have produced sufficient heat to ignite the dust. A match entering the bin with dust might have been thrown against the side wall and ignited. The explosion could have originated in the drier building. Undoubtedly a major explosion occurred in one of the drier bins, and there is some evidence which would indicate that this was the primary explosion. However, from the information available, the drier was not in operation, and no work was being carried on in the building. The condition and position of equipment in the gallery connecting the workhouse and drier indicate that the pressure wave traveled from the workhouse to the drier. If it is assumed that the original ignition occurred in the drier, the only explanation that can be made for the conditions existing in the gallery is that the explosion in the workhouse itself was of sufficient force to flash back and create pressure through the gallery in the opposite direction to which the original flash would have traveled. It is much more plausible, under the cir-

Left: The roof of the track shed was crushed by the weight of the falling galleries and broken concrete from the workhouse walls.
Right: Close-up view of the débris in the track shed.

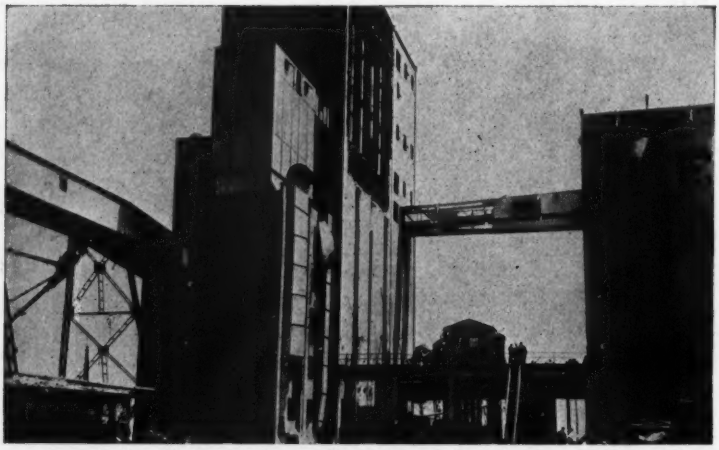
cumstances, to assume that the damage in the drier building was the result of the flash from the major explosion on the bin floor of the workhouse. The available information indicates that the major explosion was caused by a spark or flame entering the dust bin No. 40 from one of the garners or scale hoppers, or that this spark or flame may have been caused by some foreign material in the grain and dust entering the bin.

Damage to Building and Equipment.

The total damage to the building and equipment will amount to approximately $250,000. The damage to the workhouse itself consists of a large area of outside wall blown out, a large number of windows destroyed, and considerable damage to the bin floor and the motor floor. The damage to equipment consists of two wrecked garner bins, some damage to scale hoppers, and the destruction of a large amount of spouting, conveyor belting, and elevator leg equipment. Three of the belt galleries extending from the workhouse to the bin floor of the storage section were blown away from the workhouse and crashed to the roof of the track shed below. A large part of the machinery in the track shed was destroyed as well as about half of the structure itself. In the drier the principal damage consisted of blown-out windows and wrecked dust collecting equipment.

Lesson from the Explosion.

The principal lesson learned from this explosion is the value of maintaining a clean house. This explosion, serious as it was, would have been much more severe had the house not been maintained in good condition at all times. The fact that little dust was present except in the operating equipment pre-



General view of the Western Maryland Elevator after the débris had been cleared away.

vented the propagation of flames from the workhouse to the storage section. Had the flames communicated to the storage section, the damage to this structure and the large quantity of grain stored there would have been tremendous. The construction of the galleries between the workhouse and storage section with light sheet metal walls and a number of windows permitted the venting of pressure before the explosion reached the storage section. The large area of workhouse wall blown out contained few windows. On the other side of the workhouse, where more windows were present, the damage was less extensive. Wherever it was possible for the explosion to vent itself through door or window openings, little damage was done to the elevator structure. Where it is necessary to handle dust or sweepings within the elevator proper, it is desirable to run this material to a well-vented bin along an outside wall of the house. It is much more desirable to have this dusty material conveyed directly to a separate building some distance from the main plant.

Reconstruction Plans.

In the reconstruction of this plant large window areas are being provided in all sections of the workhouse walls. Special operating equipment for opening and closing these windows is being installed. Elevator leg wells are being vented directly to the outside of the building through large metal hoods. The features which proved their value in the explosion are being incorporated in the reconstruction. Belt galleries are being constructed with light metal walls and roofs. Additional natural ventilation is being provided wherever possible. The rebuilt plant, when alterations are completed, should be one of the outstanding elevators of the country from the viewpoint of dust explosion prevention.

Explosion at Hogan Mill Feed Company Plant.

*Kansas City, Missouri.**

A dust explosion resulting from the ignition of ground screenings and wheat scourings occurred at the Hogan Mill Feed Company plant at Kansas City, Missouri, about 9:55 P.M. on August 22, 1930. The explosion caused the death of two employees and injury of two others, and resulted in a property loss estimated at approximately $75,000.

General Description of Plant.

The building in which the explosion occurred was from one to two and one-half stories high, the lowest portion being about 12 feet and the highest portion (the elevator section) being about 42 feet with a cupola 8 feet high. (See sketch.) The remainder of the building was 22 to 34 feet in height. There was a concrete floor in the basement. The first and second floors were of wood construction. The roof was of wood, composition covered. The building walls were of corrugated iron on wood studding. The building was occupied as follows:

BASEMENT—Hammer mill, driven by 100 H.P. motor; fan, driven by 40 H.P. motor, for blowing ground material from mill to cyclone separator located on 2nd floor; wind trunking, screw conveyors, and elevator boots.

1ST FLOOR—Switchboards, elevating machinery, stock storage, loading equipment.

2ND FLOOR—Stock storage bins, finished stock storage, packing equipment.

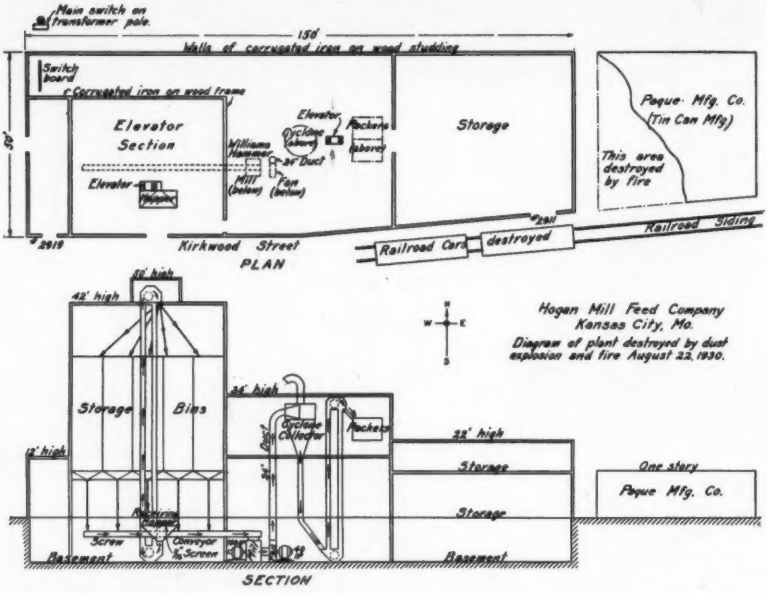
The plant was operating on three 8-hour shifts at the time of explosion. Owing to the receipt of a large order, the company had recently increased the working hours of the plant from 8 hours to 24 hours a day.

Description of Process.

Screenings and wheat scourings were unloaded from cars and dumped into a hopper, where they were picked up and elevated to bins on the second floor. When this raw material was dumped into the receiving hopper it was passed through a 3/16-inch mesh screen separator, which was supposed to remove all foreign material. From the storage bins the material was dropped by gravity to the basement and carried by means of a screw conveyor to the Hammer Mill. There was no magnetic separator ahead of the mill. A blade fan, driven by a 40 H.P. motor, drew the ground material through a screen and blew it through a 24-inch metal duct to a cyclone collector on the second floor. This cyclone collector was vented through the roof. From the cyclone collector the ground material dropped to the basement by gravity and was picked up and elevated to the packer on the second floor.

All motors in the plant are said to have been 220-volt, 3-phase squirrel cage, induction type. The switchboard was slate, and main switches are said

*The review of this explosion is based on report of Byron J. Culp, Associate Engineer, Chemical Engineering Division, Bureau of Chemistry and Sales, U. S. Department of Agriculture.



to have been in Underwriters' approved metal cabinets. Motor switches were of the oil immersed type. Wiring was in conduit.

Incandescent electric lights were used for lighting, and these are said to have been enclosed in dust-proof globes. Several extension cords were used, and bulbs are said to have been encased in dust-proof globes with metal guards for protection.

There was no heating plant of any kind in the building.

At the time of the explosion two cars of finished stock had just been loaded. These cars were standing on the railroad siding beside the plant. About one carload of raw stock was in the bins.

The elevator section was enclosed in corrugated iron on wood studding and was shut off from the remainder of the first floor by a frame door. With this door closed any workmen in the elevator section could not observe what was going on in the remainder of the first floor.

Story of the Explosion and Fire.

On the day of the explosion there was a light wind, the day was clear, and the humidity ranged from 64% in the morning to 36% at 7 P.M.

Between 8:30 and 8:45 P.M. the grinding mill and packer were shut down because of a break in a rope which formed a part of the weight mechanism on the packer. A car was being unloaded by two workmen, and this work continued until about 9:45 P.M. At this time one of the workmen was sent up to

the second floor to assist another workman in operating the packer. The plant foreman had repaired the packer and was ready to start the mill.

One of the workmen engaged in the unloading operations came into the elevator section and started the elevating machinery. He could not see the switchboard, which was located on the first floor outside of the elevator section along the west wall near the northwest corner of the building. He stated that he heard the mill machinery start but does not know how long it was running before the explosion occurred. Suddenly a blast of hot air followed by a rolling flame came through the door of the elevator section. He threw up his right arm and protected his eyes, nose and mouth from the flame. He was blown out of the open door through which loading was done. This probably saved his life, although he was badly burned around the back of his head, on his neck and shoulders and on the right arm, with which he had protected his face. He does not know what happened except that the rush of air and the flame came into the elevator section from somewhere on the first floor.

The man who was helping at the packer on the second floor stated that after the packer was repaired he was told to go to the second floor to remove bags after they had been filled. He says that the mill was running when he went to the second floor. He had removed three filled bags and was picking up the fourth when he heard a heavy report on the first floor. Almost immediately there was a flash of fire from the packer.

The foreman of the plant evidently was rendered unconscious or killed outright by the first blast of the explosion, as his body was found in the northwest corner of the building where one of the workmen said he had seen him oiling a shaft at the time this workman went upstairs to assist at the packer.

Results of Explosion and Fire.

The building was destroyed and the stock stored in the building was practically a total loss. From all appearances the machinery was badly damaged, probably most of it beyond any salvage value.

A portion of an adjacent plant was also destroyed by the fire.

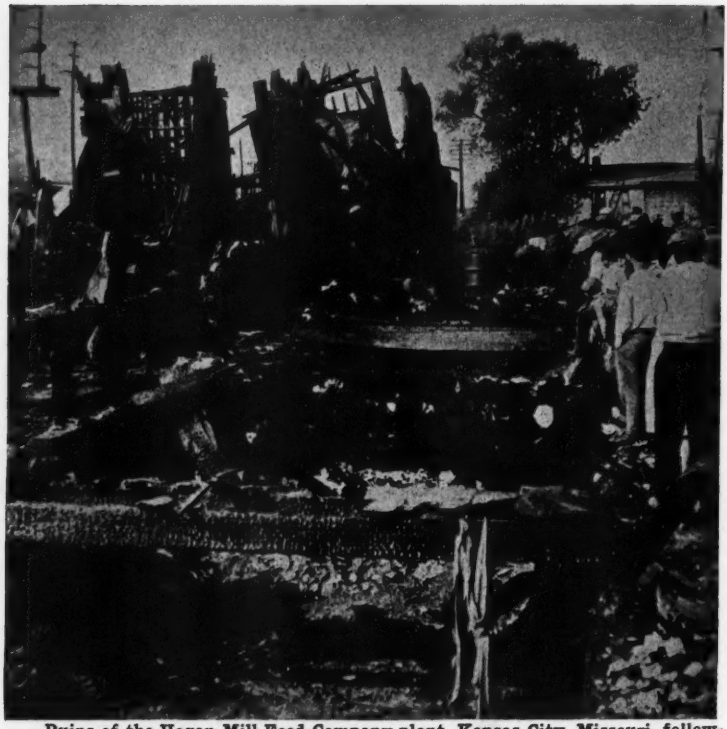
The foreman and the packer were killed. The man in charge of the elevator section of the plant and one laborer were injured.

Company officials state that a carload of raw stock and a carload of finished stock were destroyed in the plant. Two cars of finished stock standing on the siding were partially destroyed.

The loss in machinery and stock is estimated to be about $30,000. The loss on the building could not be definitely ascertained, but is estimated at $40,000 to $50,000.

Theories as to Cause.

First reports of the explosion and fire stated that the explosion occurred when an electric starting switch was thrown in. The switch blamed was one controlling either the motor operating the mill or the motor operating the fan



Ruins of the Hogan Mill Feed Company plant, Kansas City, Missouri, following the dust explosion and fire of Aug. 22, 1930. Two men were killed and two injured. The property damage was $75,000.

used for air-conveying ground feed from the mill to a cyclone separator on the second floor.

A piece of foreign material in the stock could have caused a spark when it came into contact with the steel hammers in the mill.

One or more hammers breaking away from the rotor of the mill could have caused the spark which ignited the dust in the wind trunking through which the ground feed was elevated to the cyclone on the second floor.

A small smoldering fire in the mill, possibly due to friction or overheating caused by too rapid feeding of raw stock to the mill, could have ignited the dust in the wind trunking when the fire was drawn through the fan.

Probable Cause of Explosion.

As the mill, fan and packer, as well as the elevator, had been shut down for an hour or more and had just been started up a few minutes before the explosion occurred, it is improbable that there was a sufficient cloud of dust in suspension in the room where the switchboard was located to cause an explo-

sion in the room. The walls of the building did not appear to have been blown out, but rather to have fallen in when the fire burned away the supports of the building. This would indicate that the explosion probably occurred in the machinery or in the wind trunking, elevators, conveyors, cyclone separator and packer, and that the force of the blast was insufficient to blow out the walls.

If for any reason a spark or small ball of fire had been smoldering in the mill or in the wind trunking during the time the mill was shut down while repairs were being made on the packer, this spark or ball of fire would have been blown violently when the fan was started and this would probably have ignited the dust cloud in the wind trunking.

A piece of foreign material in the stock could easily have started the explosion or started a smoldering fire which would have caused ignition.

Some previous trouble had been experienced in the mill by having the hammers break loose from the studs holding them. Company officials blame faulty hammer construction for this trouble. As many as 14 hammers had broken off in one day. If one or more hammers broke away, friction between the loose hammers and the hammers operating would cause sparks. A loose hammer could also have broken through the screen between the mill and the fan, and if this hammer struck the fan blades sparks would have resulted and this could have started the explosion.

The cause of the explosion was probably one of the following:

(1) A smoldering fire while the mill was shut down or entering the mill with raw material.
(2) Foreign material in the raw stock entering the mill.
(3) Broken hammer or hammers being struck by moving hammers or being thrown into fan blades.

When the dust in the mill or conveyors ignited, the explosion traveled throughout the conveyor casings, cyclone, elevator legs, etc. It evidently blew open a section of the wind trunking on the first floor, passed through the cyclone on the second floor, followed the conveyors and elevators to the basement and back up to the packer. The fan and mill evidently continued to run, and this caused the dust to continue to pour out of the broken ducts and out of the packer. This accounts for one of the employee's statement that the flames kept billowing out of the packer and followed him to the east end of the building. It also accounts for the fact that the fire was all through the building when the fire department arrived. The fire spread so rapidly that by the time the fire department arrived they found it impossible to throw the main electrical control switch, located on a transformer pole 20 feet or more away from the building.

Lessons and Recommendations from Explosion.

In view of the fact that the results of the explosion lead to the belief that the ignition took place in the machinery or conveyor system, we believe the following recommendations are in order.

Cyclone dust collectors should be located outside the building if possible. If this cannot be done, they should be cut off from the remainder of plant and should be adequately vented to the outside.

Magnetic separators should be provided in feed of pulverizers.

An air lift trap is desirable for removing non-metallic as well as metallic foreign substances from material to be ground.

Explosion venting devices are desirable for all buildings where dusty operations are carried on.

A sufficient number of fire escape outlets should be provided so that employees would at all times be within easy reach of an outlet in case of fire or explosion.

Adequate chokes should be provided in all screw conveyors to prevent the passage of flame and to extinguish any incipient fires in stock being conveyed.

Explosion at E. F. Carlston Elevator Company.*

Minneapolis.

About 3:05 A.M., August 26, 1930, a dust explosion with resulting fire occurred at the Devereaux Elevator and Feed Grinding Plant operated by the E. F. Carlston Elevator Company at Minneapolis. Two workmen were killed. The elevator was a total loss and there was almost a complete loss of the grain in storage, the estimated property loss amounting to approximately $100,000.

Description of Plant.

The Devereaux elevator, located at 25th Avenue S. E., and the Great Northern tracks, is owned by the William P. Devereaux Company of Minneapolis. The elevator was operated as a feed mill by the E. F. Carlston Elevator Company.

The property consisted of a 350,000-bushel iron-clad frame elevator with three small reinforced concrete storage bins detached three feet from one end of the building and connected by a metal-clad gallery. This storage space had a capacity of 33,000 bushels.

The elevator was about 55 feet x 160 feet and 70 feet high. There was a full basement with concrete floor. The remainder of the elevator was constructed of wood except for the iron-clad walls and metal roof. The basement housed the boots, shafting and screw conveyor. On the first floor were a car puller, scales, storage of both sacks and sacked feed, wood and metal cleaners, three feed grinders, electric motors, a small room for grease and oil, and a

*The review of this explosion is made possible through information furnished by A. H. Lang of Charles W. Sexton Co., Minneapolis; F. A. Cummings, Federal Grain Supervisor, Minneapolis; C. W. Harrison, Chief of Minneapolis Station, Food, Drug and Insecticide Administration; Dr. C. H. Bailey, University of Minnesota, St. Paul, Minnesota; and from report compiled by Richard L. Hanson, Asst. Engineer, Chemical Engineering Division, Bureau of Chemistry and Soils.

Burning of the Carlston Elevator, Minneapolis, following the dust explosion on Aug. 26, 1930, in which two men were killed.

small office. There were three grinding mills equipped with magnetic separators. The bin floor carried a conveyor and electric motor. The bins were of the open type.

Story of the Explosion.

For the first time in some period the mills were being operated on the night shift. Two men comprised the night crew. The mills had been shut down and the elevator cleaned on Monday, August 25. The explosion occurred at 3:05 A.M. the next morning.

Little or no information is available as to the cause of the explosion because the loss was complete and the only employees present were instantly killed.

The only witnesses were a few of the railway employees in the adjacent yards. According to them a sort of rumble was heard, followed closely by the roof being lifted high in the air and carried 150 feet from the building. The elevator rapidly became a mass of flames. Considerable débris was thrown out with the initial explosion. The blast was severe enough to rouse people from their beds about two miles away.

The concrete tanks at the end of the elevator were the means of preventing the spread of the fire to the Union Elevator near by. Although the grain in these tanks was burning briskly, the property of the Union Elevator Company was undamaged.

From the ruins it appeared that the blast must have come from near the center of the elevator. There was no part standing in this center area that could be identified with the structure or contents.

Theories as to Cause of Explosion.

Being a very old structure (built in 1886) and one with open bins, this elevator undoubtedly was a dust explosion and fire hazard, although there had been in the past no fires in this elevator except at the time of the burning of the Itasca Elevator in 1925, when the Devereaux Elevator was slightly damaged.

The feed was being ground from oats, barley and wheat screenings. The company reports that the mills never had given them any trouble. Although the grinders were equipped with magnetic separators, it is readily possible that a smoldering fire could have been produced from non-magnetic foreign material.

Explosion at Tobacco By-Products and Chemical Corp. Plant.

Richmond.

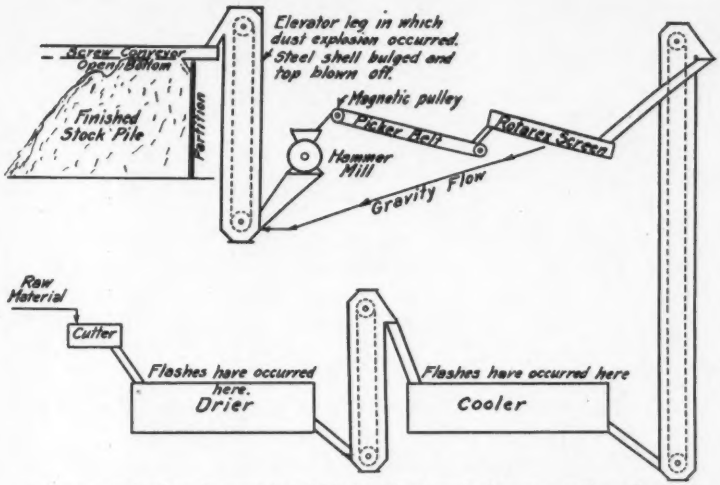
About noon, September 12, 1930, an explosion of tobacco dust of minor proportions occurred at the plant of the Tobacco By-Products Corporation at Richmond. This is the first tobacco dust explosion investigated by the Chemical Engineering Division of the Bureau of Chemistry and Soils, and, although the damage from the explosion was of minor proportions, it is considered important to observe the conditions under which the explosion took place.

Description of Process.

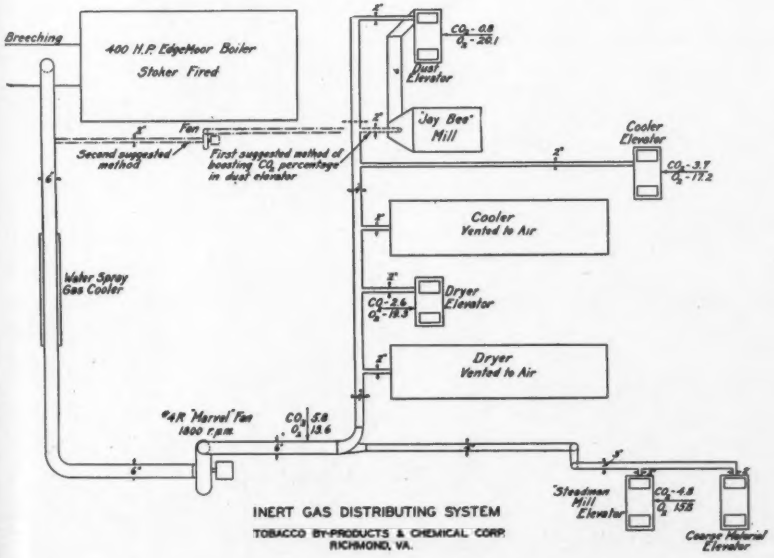
The company was grinding tobacco for use in the manufacture of an insecticide known as "Black Leaf 40." For this purpose stems and tobacco scrap are used. The materials are received at the plant and passed through a drier to reduce the moisture content to a point where it can be readily pulverized. The raw material is then put through a cooler to reduce the temperature. A hammer mill was used in grinding operations. This mill discharged directly to the boot of a steel shell, single leg, bucket elevator, approximately 20 x 50 inches in cross-sectional area.

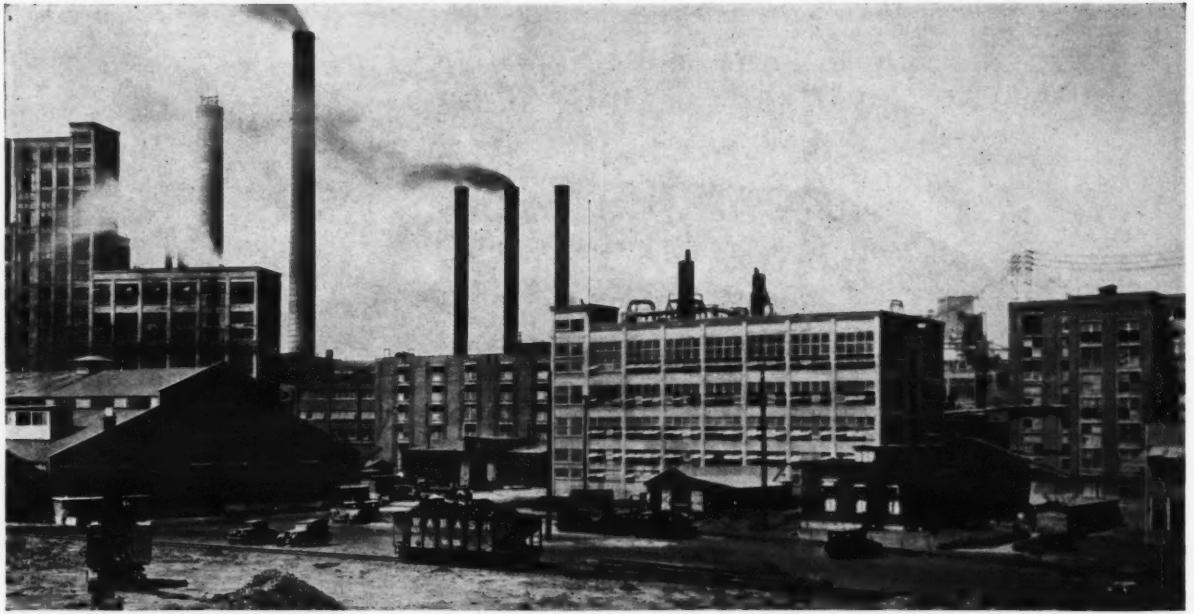
Story of the Explosion.

The explosion apparently occurred in the elevator leg and developed sufficient pressure to bulge the sides of the steel sheet three or four inches out of alignment and blow off the head by shearing the rivets. After the explosion the company placed cardboard tops on all elevator legs to relieve pressure



Arrangement of equipment in which the dust explosion occurred on Sept. 12, 1930, at the plant of the Tobacco By-Products and Chemical Corp., Richmond, Va.





Plant of the A. E. Staley Manufacturing Company at Decatur, Ill., scene of the dust explosion in which six lives were lost on Sept. 20, 1930. The casualties were confined to the ground floor of the Starch House (center of picture), where the explosion originated. Owing to the potential violence of starch dust explosions and the necessary communications between various units of a starch manufacturing plant, an explosion in an old style starch plant might have caused a large loss of life and completely destroyed the plant. In this case, owing to the provision of liberal window area and compliance with other recommendations of the N.F.P.A. Committee on Dust Explosion Hazards, the casualties were limited to the men in the immediate vicinity of the point of origin of the explosion, and the property damage to $5000.

should an explosion occur. Extra precautions were taken to remove any material which might cause a spark or smoldering fire while passing through the hammer mill. Brushes were installed on the elevator boot shaft to remove static charges. Other equipment in the plant was also grounded. Vents were installed on the driers. The accompanying diagrammatic sketch shows the arrangement of the plant equipment.

The recommendations were made for the installation of the following items for prevention of similar explosions:

1. Inert gas system with atmospheres of low oxygen content to prevent flame propagation in grinding and conveying systems (similar to sketch on preceding page).
2. Choke conveyor or revolving damper between the hammer mill and the elevator boot to prevent the passage of flashes or smoldering material capable of igniting the dust cloud in the elevator leg.
3. Vents on the elevator leg extending through the outside wall of the building at all floor levels to release any pressure due to dust ignition. Vents should be equipped with dampers or seals to retain the dust inside the leg and prevent choking of the vent pipe.
4. Slides or chutes to distribute the finished stock now dropped in piles from an open bottom screw conveyor to prevent creation of heavy dust clouds.

Explosion at Staley Manufacturing Company.

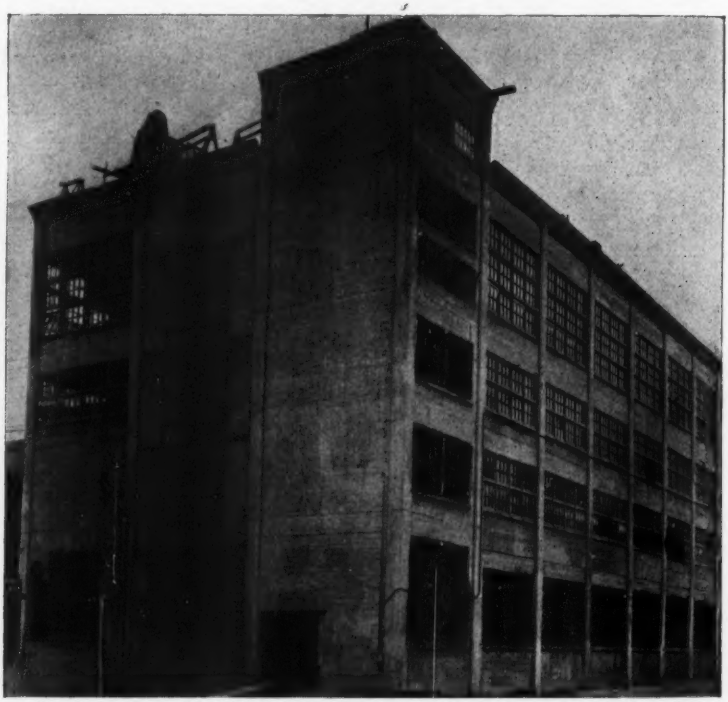
Decatur, Ill.

On Saturday, September 20, 1930, about 4:45 P.M., an explosion occurred in the starch house at the A. E. Staley Manufacturing Company plant at Decatur, Illinois. The explosion resulted in the death of six workmen (primarily from burns and resulting effects) and injuries to several others. Property damage, however, was minor, amounting to approximately $5000.

An investigation of this explosion was undertaken by the Chemical Engineering Division, Bureau of Chemistry and Soils, for the purpose of determining the possible cause of the explosion in order to assist engineers of the division in developing further means of prevention. In the investigation of this explosion every facility and courtesy was extended by the A. E. Staley Manufacturing Company. The results and findings of the investigation are embodied in the following report.

Description of Operations.

The explosion and resulting fire occurred in the starch house known as building No. 21. The dry starch, after being taken from the drying kilns, was transported by means of power operated transfers and tray loaders to the starch dumping pit which was located on the first floor. The starch trays, of wooden construction, were dumped by hand, two workmen being employed in this process. The dumped starch passed through two rotary feeders (of the butterfly valve type) into a 20-inch pipe of No. 10 gauge steel. These rotary feeders were driven by two motors, 1 H.P., 440 volts A. C., each feeder being driven by an individual motor.

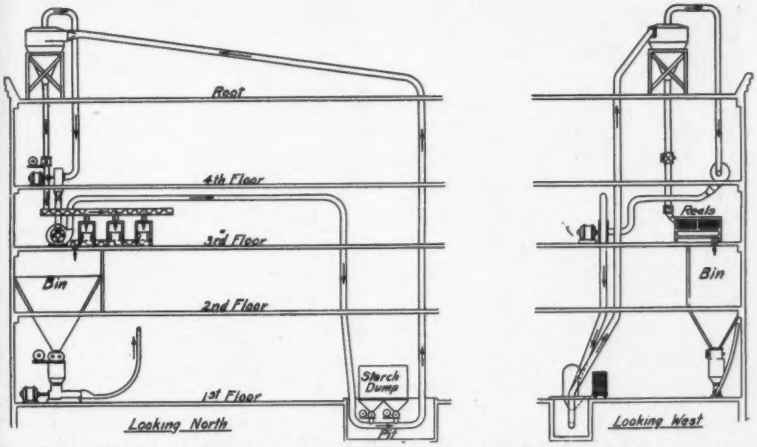


South and east sides of the Starch House, showing damage to windows. Most of the damage occurred on the first floor where the explosion originated, and on the stair shaft in the corner. The large glass area relieved the pressure of the initial explosion and prevented far greater damage. (This picture was taken three days after the explosion, when many of the windows had been replaced; it has been retouched to show the original damage.)

The starch, after being discharged from the feeders, was carried by air suction through a 20-inch vertical pipe extending from the dumping pit (underneath the first floor) through the second, third and fourth floors to the roof of the building, where the pipe turned and passed over the top of the roof to a cyclone dust collector.

This cyclone collector discharged the starch through a 16-inch pipe leading to a revolving feeder on the fourth floor, and the feeder discharged to a spiral conveyor, which in turn discharged to three reels on the third floor. These reels discharged into a receiving bin on the second floor, and this bin in turn discharged the starch into a Fuller-Kinyon pump that pumped the starch through pipes to the packing department.

The air suction for this starch system was produced by two 60-inch fans, 1200 R.P.M., located on the fourth and third floors on the return air side of



Sections of Building No. 21, the Starch House, showing the starch conveying system in which the dust explosion occurred.

the system. The exhaust from the cyclone dust collector on the roof passed through a 24-inch pipe to the fan on the fourth floor and through this fan to another 24-inch pipe leading to the fan on the third floor. The fan on the third floor discharged to a pipe of the same size which passed across the third floor near the ceiling and made a right angle turn, passing through the third floor and on down to the second floor. This pipe made a slight bend in the ceiling of the first floor. It carried the return air back to the dumping pit, entering the line at a point directly below the feeders on the west side of the pit. There was an opening 20 inches by 24 inches in size in the return pipe to permit the intake of fresh air to replace air escaping in operation of the system.

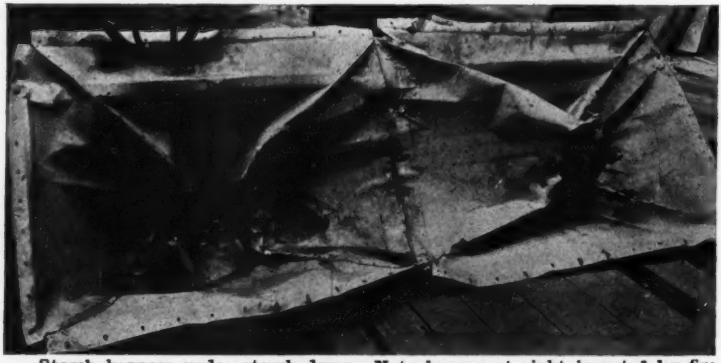
Story of the Explosion.

The explosion was practically confined to the starch house and did not extend to any of the other buildings. There were sixteen men at work on the first floor of the building. Six of these men died in the hospital from burns within a few days after the explosion. These men were located in the immediate vicinity of the starch dumping pit at the time of the explosion. The other ten men escaped from the first floor without any injuries. There were five men on the second floor, three on the third floor, and five on the fourth floor, all of them escaping from the building with practically no injuries.

Results of the Explosion.

DAMAGE TO STARCH CONVEYING SYSTEM. With the exception of the destruction of the cyclone dust collector on the roof and the damage to the fans on the third and fourth floors, the effects of the explosion were confined very largely to the first floor in the immediate vicinity of the starch dumping pit.

Two views showing the violence of the explosion. Left: Starch receiving pipe and connection taken from the dumping pit. The pipe was 20 in. diameter, constructed of No. 10 gauge steel. Right: Pieces of the cyclone dust collector on the roof, showing the effects of the explosion.



Starch hoppers under starch dump. Note hopper at right inverted by fire and explosion.

The explosion appeared to be most violent in the pit. It opened up the 20-inch pipe and bent it into the condition shown in the accompanying photographs. The discharge pipes leading from the feeders to this 20-inch pipe also were badly bent, and the one on the west was badly shattered. The hoppers from the dump to the feeders were blown out of position, and the bottom of the hopper on the west side was pulled upward and inverted from its original position. Both feeders and the driving motors were found on the floor of the pit after the explosion. The hood above the dumping pit was blown down from its original position.

The inside cylinder of the cyclone dust collector was blown off and also the discharge to the cyclone pipe. The top of the cyclone also was blown off.

The return air pipe from the cyclone was torn off level with the roof in two separate pieces. The straight pipe was found lying on the roof. The two elbows from the cyclone were blown from the roof of the starch house to a near-by building. The elbow of the fourth floor fan was blown off and torn in several pieces. The elbow was blown to the floor and flattened out. The vertical piece leading through the ceiling of the fourth floor was intact.

The return air pipe leading from the exhaust of the fourth floor fan to the third floor fan was not affected. The return pipe was intact to the second floor, but from the second floor to the starch dumping pit it was torn down.

Damage to Window Glass. The pressure from the explosion was very effectively vented by the window glass area on the first floor. It apparently was relieved sufficiently to prevent a violent secondary explosion. All windows on the south, west and east sides of the first floor, and the greater part of the glass on the north side were blown out.

On the east side of the second floor approximately three window sashes were blown out, a few on the south side, and some on the north side. On the third floor only one pane of glass was blown out on the east side, and only one full sash and one pane on the south side. Apparently no damage was done to the windows on the fourth floor.

The windows in the stairway leading from the first floor to the fourth floor were on the south side of the building, and all were blown out. Also one sash at the top of the stairway, on a level with the roof of the building on the south side, was blown out, while the other sash apparently was intact. The explosion wave traveled up the stairway from the first floor and vented itself through the glass area provided.

Damage to Sulphur Elevator. A sulphur elevator extending from the sulphur pit on the first floor to the sulphur hopper on the fourth floor was badly burned by the fire from the explosion. This sulphur leg was not operating at the time of the explosion.

Plant Conditions.

The conditions at the Staley plant, in so far as they related to operation and maintenance, would compare very favorably with other starch factories. The hazard of dust explosions and resulting fires was fully appreciated by the officials and workmen, and a well-organized safety and inspection corps was provided.

The plant record is very good, well above the average industrial plant where explosive dusts are created during operating processes. It was generally understood that all precautions should be observed for the prevention of dust explosions. Safety engineers devoted their attention to safeguarding operating processes, and by means of special meetings and conferences the importance of safety measures pertaining to dust explosion prevention was presented to the workmen. The class of men employed in this plant was above the average, practically all of them being Americans with a high degree of intelligence.

Weather Conditions.

Weather Bureau records would indicate that the temperature at 5:45 P.M., when the explosion occurred, was approximately 60° F. The data available indicate that the relative humidity of the outside atmosphere in Decatur at the time of the explosion was between 50 and 55 per cent.

Theories as to Cause of Explosion.

The investigation of this explosion indicated that the officials and workmen of the Staley Manufacturing Company had not been able to arrive at a definite conclusion as to the cause. Many theories were advanced when detailed statements were taken, but all were based largely on opinion rather than upon actual evidence. The four main theories, however, after elimination of the others that are not of major importance, can be listed as follows without attaching any significance to their order:

1. Sparks from nails or metallic substances entering hoppers and feeders at starch dumping pit.
2. Electrical sparks from (a) motors in pit, and (b) motors or other electrical equipment on first floor.
3. Static electricity in starch handling system.
4. Sparks from fans on return air side of starch system.

Conclusions as to Possible Cause of Explosion.

A very thorough investigation has been made of this explosion and the resulting fire. It has been an extremely difficult task to determine the definite cause. After a study of the conditions at the plant, a study of the statements of the twenty-three survivors in the building where the explosion occurred, and the statements of twenty-two observers in near-by buildings, and a very thorough study of all available data, much more comprehensive than in the average case, it has been possible to reach the following conclusions:

It appears that the original or primary explosion occurred in the starch handling system. The fire from this explosion spread to the sulphur elevator leg, where a second ignition of sulphur dust or minor explosion took place. From a study of the effects of the explosion it appears that it originated on the return air side of the starch handling system, presumably at a point in or near the fan on the third floor. The original ignition may have been due to the ignition of starch dust by fan sparks.

The original ignition could have propagated from this point through the return pipe to the starch dumping pit. As a result of the starch dust present in the pit the explosion evidently reached its greatest violence at this point. It could have passed through the 24-inch by 20-inch opening in the pipe, or by opening up the 20-inch horizontal pipe it could have blown out into the pit and up into the first floor and then up the stairway to the floor above.

The flash of burning starch dust could then have passed up the starch receiving side to the upper floor, and on to the cyclone, relieving itself by damage to the cyclone and connecting pipes on the roof. Although considerable pressure was vented at the cyclone, the remaining flame and pressure

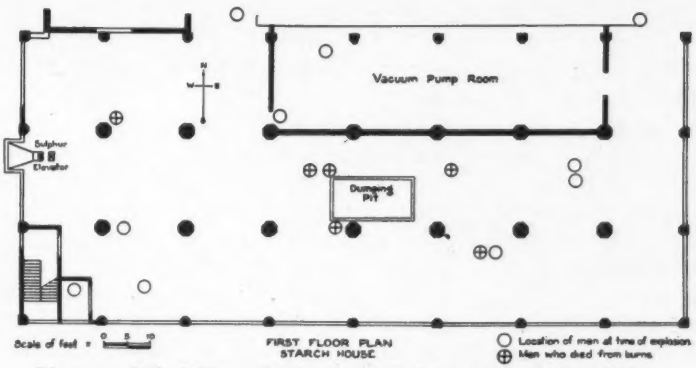


Diagram of First Floor, showing location of men at time of explosion.

could have passed on down to the fourth floor fan, blowing off the elbow and pipes, and then on to the third floor fan, where it opened up the casing and stopped. It appears that the explosion originated in the vicinity of the third floor fan on the return air side of the system.

Lessons from the Explosion.

This explosion raises a very serious question as to the relation of an air conveying system of this type to the frequency of dust explosions. In ordinary operation when the starch is entering the system it is quite likely that the concentration is too heavy for ignition. When the dumping operations cease, however, the concentration approaches the explosive range and the hazard is therefore greatest. The fact that this explosion occurred during the period between dumping operations sustains this conclusion. Any ignition source introduced into the system at the time this concentration is reached would, under favorable conditions, result in an explosion.

The value of large window glass area has been well proved in this explosion. The explosion was localized and the extent of damage limited by the glass area, which effectively vented the explosion on the first floor. This provision for explosion relief was so effective that the primary explosion did not build up sufficient pressure to reach the secondary stage. The provision for large glass areas should be continued in the construction of buildings where combustible dusts are created during manufacturing operations. The Dust Explosion Hazards Committee has recommended this safety measure in all of its dust explosion prevention regulations.

It is important to note that screw conveyors and elevator legs for handling dry starch were not in use in this building. This procedure was followed to eliminate the ordinary hazards encountered in operation of this type of equipment and to afford additional safety in prevention of dust explosions and fires resulting therefrom.

Two Fires in Buildings Under Construction.

Two fires of more than ordinary interest have occurred during the past few months in buildings under construction. The first, in the Pennsylvania State Education Building in Harrisburg, is noteworthy because of the large loss occasioned and the type and occupancy of the building involved. The other is of interest because of its origin forty-seven floors above the street in New York's most modern skyscraper, the Empire State Building. Thanks to adequate fire protection facilities this latter fire was extinguished with comparatively small loss.

State Education Building Fire, Harrisburg.

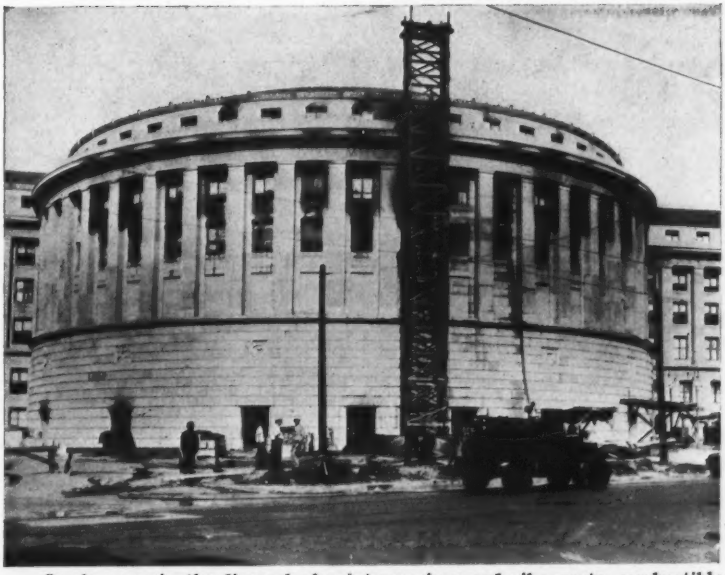
Early on the morning of October 3, 1930, a fire occurred in the auditorium section of the State Education Building at Harrisburg, Pa., which damaged the structure to the estimated amount of $500,000 or more. The building was approaching completion and it had been planned to move some departments into it by December 1st.

The building is of fire-resistive construction, seven stories in height. It is to house the State Educational Department, the State Library and the Welfare Department. The section where the fire occurred is to contain the State Library and the auditorium. This section is circular in shape and has an area of approximately 15,000 square feet on each floor.

The auditorium on completion is to be the show place of the Capitol, and according to the architects will be one of the most beautiful rooms of its kind in America. The ceiling as originally designed will be the crowning decoration of the room, representing the sky, with a great electrical sunburst in the center and hundreds of stars in their correct location represented by crystal electric lights. This provides the entire illumination for the auditorium. The central sunburst of art plaster and metal had been completed the day prior to the fire.

To facilitate the work of decorating, the auditorium had been filled with wooden scaffolding to the extent of approximately 100,000 feet. China wood oil had been applied to the walls as sizing. It had been put on too thick and would not dry, so it was decided to remove same. In this operation brushes soaked in turpentine were used to soften the china wood oil, the walls were scraped with putty knives and then washed with benzine applied with rags.

The report of the fire at the State Education Building in Harrisburg, Pa., has been compiled from data furnished by the Underwriters Association of the Middle Department (Member N.F.P.A.) and Chief M. M. Tawney (Member N.F.P.A.) of the Harrisburg Fire Department. The data relative to the Empire State Building fire in New York City were furnished by the New York Board of Fire Underwriters (Member N.F.P.A.).



Carelessness in the disposal of paint scrapings and oily waste, combustible scaffolding, freshly painted walls, and a delayed alarm were all factors in the $700,000 blaze which ruined the auditorium section of the State Education Building at Harrisburg, Pa.

The waste rags and scrapings were placed in cardboard cartons and their subsequent spontaneous ignition was undoubtedly the cause of the fire. The cardboard cartons were apparently left on the upper scaffolding when work ceased for the day, for, according to the watchman who discovered it, the fire was dropping through the scaffolding from the upper levels.

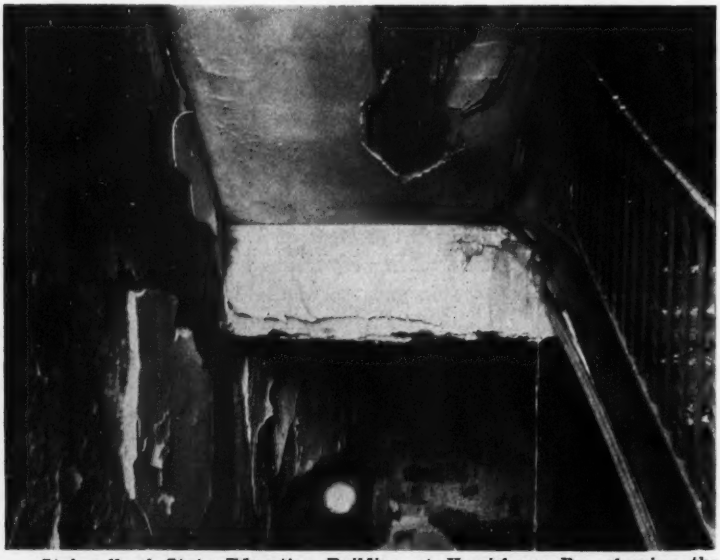
The fire was discovered by a watchman at 3:50 A.M. In spite of the fact that a public fire alarm box is located approximately 250 feet from the building he, with another watchman, went to a workmen's shanty about twice the distance and hunted telephone numbers in order to call the fire department. The first telephone call was received by the fire department at 4:10 A.M., and two companies responded. The first company to arrive sent in an alarm from the street box at 4:14 A.M., which was followed by a general alarm at 4:19 A.M. on the arrival of the chief.

By the time the fire department reached the scene the combustible scaffolding and the freshly painted walls were all ablaze and heavy black smoke was rolling from the windows of the auditorium wing. The drafts from the entrances on the first floor drove the heat and flame upward and the felt-lined pipes of the ventilating systems acted as flues. Streams were directed at the top of the auditorium in an effort to keep the steel work cool. By forming a water curtain between the auditorium ceiling and the steel work over the

dome it was possible to keep the steel members sufficiently cool to prevent their warping. This was accomplished by placing heavy streams in operation through the windows above the dome. Large pieces of plaster were ripped off by the force of the hose streams and as they dropped several firemen narrowly escaped serious injury. Sections of marble and other trim were washed down stairways and the fire-fighters were forced to dodge them as they made their way to the auditorium to fight the fire at close range. The heat caused the warping of the steel members of some of the stairways, and some cracks developed in the limestone blocks in the exterior walls.

The damage to other parts of the building was done by back drafts of heat and smoke. These were of frequent occurrence during the fire. The auditorium section resembled a huge beehive with no openings at the top. The smoke and gases accumulated at the top until they reached such volume that they came down to the openings beside the stage and aisles and then blew out into the main corridors and rooms in other parts of the building.

Contractors who viewed the ruins stated that the entire section, with the exception of the outer stone work and the structural steel, would have to be rebuilt. It was said that the steel trusses between the main building and the auditorium were somewhat sprung. The marble in the main auditorium and stairways was ruined and will have to be entirely replaced. In addition to the



Stairwell of State Education Building at Harrisburg, Pa., showing the damage done by heat warping the steel members of the stairway and plaster broken from the walls.

devastation of the auditorium the whole interior decoration and finish of the office section of the building will have to be done over. The entire building was damaged by smoke, and much of it was water soaked.

Empire State Building Fire, New York City.

The Empire State Building on the site of the former Waldorf-Astoria Hotel at Fifth Avenue and 34th Street, still in the course of construction, has been of more than ordinary interest due to its height, area, and special features of equipment, including the erection of a dirigible mooring mast. (See Frontispiece.) The height of the building to the 85th floor is about 1044 feet, with the mooring mast extending about 206 feet higher. The area of the grade floor is approximately 49,000 square feet. The steel frame weighs in excess of 56,000 tons, was begun in March and completed in November, 1930—a record. The cost of the land and building is said to have been $55,000,000. Fire insurance carried amounts to about $20,000,000.

During construction operations particular care has been exercised in safeguarding fire hazards. Excellent temporary fire protection and central station watch service has been maintained, and extreme care has been exercised in the disposal of combustible waste and refuse. There were some 3500 employees on the job. To care for this large number of workers several temporary lunch rooms were necessary. One of these lunch rooms was located on the 47th floor, enclosed in a temporary room of corrugated iron on wood framework. The furnishings consisted of wooden tables and benches, and the kitchen equipment of portable electric heaters.

At 6:55 A.M. on November 5, 1930, a fire occurred in this lunch room. A watchman making his rounds passed the room about 6:00 A.M. and states he saw no evidence of fire. The room had been locked up the night before and apparently one or more of the electric heaters had not been turned off. An alarm was immediately turned in through the supervised watch and alarm system in the building. The fire department responded and, using hose streams supplied by the building equipment, promptly extinguished the fire, but not until it had done quite some damage. The combustible furnishings of the room were practically destroyed, the walls blackened by smoke and soot, the machine and switchboard room two floors below was damaged by water, and two or three bays directly above the fire were damaged to some extent. None of the fireproofing on the steel members appears to have been in any way damaged.

This fire again emphasizes the additional hazards in buildings under construction over completed structures and the need for the utmost vigilance in the safeguarding of such hazards. In this instance extreme care was exercised in the protection of major operations, yet this comparatively small lunch room resulted in a fire damage of approximately $5000. This loss might have been much greater but for the prompt notification to and extinguishment by

the fire department. It appears indeed fortunate that favorable consideration had been given the suggestions of the New York Board of Fire Underwriters in providing central station watch and fire alarm equipment for the prompt detection and transmission of fire alarms, that the elevators were in readiness to transport the firemen and hose to the fire, and that the standpipe equipment and electric pump were ready for service in extinguishing the fire. These are all vital contributing factors in safeguarding the fire hazard in tall buildings, particularly when in course of erection.

Brooklyn Oil Refinery Fire.

One of the most spectacular waterfront fires that New York has witnessed in many months occurred just before midnight on December 3, 1930, in the Pratt Works of the Standard Oil Company of New York, located on the East River in Brooklyn. The fire was of unknown origin and started with an explosion in a horizontal steam still. This still was 15 feet in diameter, 50 feet long, and contained approximately 8000 gallons of product.

The explosion was of considerable violence and blew out the ends of the still. This demolished a portion of the brick retaining wall in close proximity to the head of the still and also ignited the contents of the still's receiving tanks, the roofs of which were not gas-tight. The blazing contents of the still and tanks flowed out and found their way to the river through a sewer approximately 12 feet in diameter. As the tide was low at the time, the discharge from the sewer spread out in a thin film over the surface of the water, forming a burning area of considerable size.

The fire appeared to separate into two parts, one along the river fed by the burning oil discharged by the sewer, and the other in the refinery. This required the separation of the fire fighting forces into two units. On the river side the prompt and efficient action of the fireboats *New Yorker, Zophar Mills* and *John B. McClellan* was a factor in checking the flames. The storage warehouse containing case goods, owing to its fire-resistive construction, did not catch fire, nor was the fire communicated to its contents.

On the land side, city firemen, in conjunction with the company's own fire brigade, quickly brought the fire under control and kept it from spreading to other tanks and buildings within the plant as well as the large gas holders of the Brooklyn Union Gas Company situated less than 100 feet away. The fire, which started at 11:20 P.M., was under control an hour later and entirely extinguished at 1:30 A.M.

This report has been prepared largely from data furnished by F. E. Ellis (Member N.F.P.A.), Chief Engineer, Standard Oil Co. of New York.

At the time of the initial explosion the refinery employees were at work as usual, but no one was injured. There was no injury to persons other than employees in the subsequent explosions and fire which followed. One employee, believing that papers in an adjoining building might be destroyed, endeavored to break a wired glass window in the fire-resistive door with his hand and as a result suffered a severe laceration.

Oil fires are usually spectacular, but if the plant is constructed of non-combustible materials the fire may in all probability be confined to the burning oil and the damage limited to that caused by the initial explosion. This was the case in the Pratt Works fire and is the reason why it was extinguished in so short a time. The loss, according to latest estimates, will not exceed $20,000 and is limited to one steam still, one cluster of piles used for mooring boats, and approximately 300 barrels of product.

International.

Firemen fighting the Brooklyn refinery fire. Note hole in the brick wall ruptured by the explosion, and section of still blown into the street.

Cypremort, Louisiana, Sugar House Fire.

Report by H. L. McLean.

A fire of unusual interest, which was fought entirely with private and sub-standard equipment while two public fire departments stood by, occurred on June 23, 1930, in the sugar house of the J. M. Burguieres Co., Ltd., at Cypremort, Louisiana. The fire was remarkably well handled, considering the circumstances, and reflects a great deal of credit on those participating in the battle.

The buildings involved in the fire were a frame iron-clad granulator house, a brick warehouse (50 x 210 feet) adjoining, another brick warehouse (50 x 82 feet) to the north, and a small oil pump house.

The fire was discovered at 6:20 P.M. in the western end of the granulator room by an employee, a sugar weigher, who was at the time about fifty feet from the opening connecting the granulator room and the brick factory building. He detected the odor of smoke, rushed to the opening and noticed that the walls at the rear and west side of the granulator room were ablaze, An alarm was given and the employees, under the supervision of one of the owners, and the chief engineer undertook to battle the blaze. At the same time assistance was requested by telephone from the towns of Franklin and New Iberia, both about twenty-five miles away. Private protection was available in the form of 1½-inch wire-wound hose lines and 2-inch cotton rubber-lined fire hose supplied under a limited tank pressure.

Despite the preliminary efforts of the fire fighters, it was not long before the blaze had spread from the granulator room to the brick warehouse building. Employees with a small line under good pressure made a determined stand along the side of the mill and stopped the fire at this point. Other lines were carried to the roof and were used to cover the frame iron-clad boiler house and the cane shed, preventing the spread of the fire to these buildings except in a few minor places readily extinguished. Other crews were distributed to keep the rest of the plant wet down, and the fire was confined to the building of origin and two brick buildings previously mentioned.

As the fire progressed, the brick warehouse at the north end of the plant caught fire. The blaze at this point caused sufficient heat to ignite some timbers in the yard on which boilers were stored and a small oil pump house about 8 x 10 feet. This pump house, which was vital to the operation of the plant, was soon enveloped in flames. Mr. Burguieres, observing a Southern Pacific locomotive in the vicinity, had it switched in on his own track within ten feet of the oil house. The engineer of the locomotive opened the blow-off

valve and by running back and forth past the building extinguished the burning oil and wood with steam.

At the same time the chief engineer of the plant showed great resourcefulness in converting a gasoline driven geared pump, which had not been damaged, by means of a rubber hose, so that the oil supply was interrupted only for about fifteen minutes. During this time the boilers, of course, received no fuel and steam was being used up very rapidly. To prevent loss of steam due to ruptured pipes when the fire entered the main building, the chief engineer cut off the steam lines by breaking some pipe fittings and plugging up the openings so that he lost no steam of any consequence.

There was a small tower tank located over the frame structures between the warehouse and the boiler house. During the fire a large pipe from the bottom broke, releasing all of the water on these frame structures and completely drowned the fire at this point.

It was rather unusual that the pump which supplied the water pressure almost continuously for many hours, operating at full stroke, was an ordinary circulating single cylinder pump not intended to be used as a pressure pump at all, having approximately the same size steam and water ends. Pressure maintained on the boilers, however, was over 100 pounds, and therefore a good head was obtainable. In other words, an ample supply of water was available for all the hose which was at the plant.

The Franklin fire department arrived with a new pumper, and while there was plenty of water in the bayou the men who came with the apparatus did not seem to understand how to operate it and were unable to do anything. The department from New Iberia did not even make an attempt to assist, and seemed to have come to the scene for the purpose of taking a ride and idle curiosity.

In conclusion, it is evident that if this sugar house had been equipped with the proper fire fighting equipment, with the same zeal that was shown, it might have sustained a slight damage, but would have never been destroyed unless through some unforeseen means. Great credit is due all who assisted in holding down this blaze and confining it to a loss of approximately $145,000.

Automobile Fire Hazards.

The almost universal use of the motor vehicle for business and pleasure has, like the development of many modern industrial processes, brought with it certain inherent fire hazards. The presence of these hazards has been productive of a large number of fires which have increased annually in proportion to the number of pleasure cars and trucks registered.

For the most part these fires are of minor importance from a loss standpoint. Nevertheless they are becoming a very considerable part of the work of the fire department of nearly every city and large town. In spite of the fact that the majority of these fires entail but a trifling loss or cause no damage at all, there have been sufficient instances of serious damage to the car or truck and loss of life and injury to the occupants to warrant serious consideration of the problem.

The inherent fire hazards of motor vehicles fall into three general groups —those attributable to design and construction, those chargeable to improper operation, and those due to carelessness in the handling of gasoline.

The hazards of the first group, those attributable to design and construction, are being largely overcome by modern automotive engineering practice. These include the safeguarding of gasoline tanks and fuel systems, the development of carburetor backfire deflectors, more careful installation and thorough insulation of electric wiring and equipment, and proper clearance for the exhaust system.

In the automotive field Underwriters' Laboratories has been active in safety research. Since the beginning of its work it has consistently recommended that the gasoline tank on passenger cars be located at the rear of the car and not enclosed within the body. The reason for this is obvious, for if fire occurs following a collision in a car equipped with a tank located under the driver's seat or in the cowl the fire is very likely to envelop the entire car and trap the occupants. While fires may follow accidents to cars equipped with tanks located at the rear, such fires are less likely to confine and burn the occupants. This contention is amply supported by actual fire experience as indicated by N.F.P.A. fire records.

The Fuel System Hazard.

In addition to the serious hazard due to locating the fuel tank improperly is the hazard brought about by the presence of the vacuum tank, usually

---

Much of the data contained in the discussion of automobile fire hazards has been abridged from an article, "Fire Hazards of Automotive Vehicles," by George D. Becker, appearing in *Laboratories' Data* for September, 1930. Acknowledgment is also made to the *Travelers Standard* for September, 1926, from which fire record data have been obtained. —Ed.

Laboratories Data.

Underwriters' Laboratories makes tests to determine the fire hazard of automobile engines and equipment. This picture shows the testing of a backfire deflector attached to a carburetor.

located on the cowl adjacent to the motor. The presence of this tank with its contents of gasoline creates a fire hazard in event of an accident or a leak in the tank itself. In either case gasoline might be spilled on the hot motor and the resultant fire might spread to other parts of the car, causing serious damage and endangering the lives of the occupants. The use of the fuel pump on many of the newer cars has practically eliminated this hazard, for when the operation of the motor ceases the flow of gasoline from the main tank is stopped. Other parts of the fuel system, such as fuel pipe lines, fittings strainers, valves and gauges, should be so constructed as to withstand severe service without leaking gasoline. This calls for care in installation, particularly in regard to fuel piping to prevent failure from vibration and road shock.

Carburetor Backfire.

One of the major hazards of the fuel system in the past has been the possibility of backfire in the carburetor. This often results in an intense flame being emitted into the motor compartment, with the resultant ignition of the car. When air cleaners were first introduced they were intended to perform only the service which the name implies. Laboratory experiments and tests, however, indicated that some air cleaners were effective as backfire

deflectors in that they restricted and prevented backfire flames from reaching the motor. This led to the development of carburetor backfire deflectors of considerable merit, and recent fire records indicate a marked decrease in the number of fires due to carburetion, particularly in cold weather when the hazard is greatest.

The Electrical System.

The fire hazard features of the electrical system relate for the most part to the proper spacing and securing of current-carrying parts and to the use of suitable insulating material. The location of generating and distributing units with respect to other spark or flame producing devices is also an item for consideration.

The first requisite in regard to wiring is to make sure that wires and cables of sufficient current capacity with proper insulation are used. To guard against failure in the wiring system resulting from broken-down insulation due to saturation by oil and gasoline, wires must be located away from devices which might cause such a condition, and where there is a chance of impregnation by oil or gasoline conduit of a suitable type should be employed.

Mechanical injury may be prevented by locating wires away from movable parts, such as fan, brake pedal, etc., and by providing protection in the form of flexible conduit. One of the worst things to be combated in all automotive design is vibration. In common with the installation of fuel piping, vibration must be guarded against and supports provided in locating wires and cables. Supports usually in the form of clips, secured by bolts and lock washers, are used. The clips are provided wherever a length of wire presents an opportunity for chafing. The use of harnesses whereby many leads are bunched and enclosed in a braided covering has materially assisted in reducing the possibility of short circuits resulting from chafed and cut insulation.

Fuses or circuit breakers are desirable to protect all electrical circuits, except the ignition and starting-motor circuits, against electrical burn-outs. The reason for excluding the ignition circuit is because no device which may cause failure of that circuit for any reason whatever should be installed therein. As for the starting motor circuit, the circuit flow is so high that overload protection is impracticable. The amperage sometimes reaches a maximum of 700 and is usually of short duration.

The Exhaust System.

The exhaust system includes manifold, exhaust pipe, muffler and heaters. Proper spacing should be maintained between all parts of this system and combustible materials. If the pipe from the manifold to the muffler cannot be installed far enough away from the body and toe-boards, asbestos sheeting should be used to cover the wooden members, or the exhaust pipe should be lagged. The muffler should be constructed strong enough to withstand, with-

out failure, exhaust line explosions. If sufficient strength is not built into this unit the explosions will result in opened muffler seams and subsequent release of hot exhaust gases near the body of the car.

A double hazard is presented in the use of exhaust heaters which are employed for warming the riding compartment. One is high temperature and the other is leakage of carbon monoxide exhaust gases. The production of excessive temperatures may be controlled by properly flanging, insulating, and spacing of heated parts from combustible parts of the body.

From the foregoing it would appear that from an engineering standpoint the modern motor car can be safeguarded against fire within all reasonable limits provided it is handled in a careful manner. Unfortunately, however, the "human element" enters into the problem and improper operation may well be regarded as an inherent fire hazard of motor vehicles.

The Human Element.

The average driver must be considered in all his moods and in every state of mind and body in which he may attempt to operate his car. He may or may not be competent as a driver, and the car may be maintained in an excellent state of cleanliness or its motor may be covered with oil and grease. The pleasure car is subject to abuse of thoughtless, reckless and often intoxicated operators; the commercial car is destined to be cared for by men of more cautious temperament, as a rule, but possibly less alert and intelligent. Neither type of machine or operator can be overlooked in attempting to reduce the potential fire hazard to a minimum.

The third inherent hazard of motor vehicles is due to carelessness in handling gasoline. The old adage that "familiarity breeds contempt" is unfortunately all too true—a contempt whose annual cost in life and property

International.

While being refilled the gasoline tank (located in the cowl) burst into flame, with the result that the car was practically a total loss.

is so great that it cannot be ignored. There are many persons who fail to treat gasoline with the respect which it deserves, and as a consequence these careless individuals endanger not only themselves but others who are in no way responsible for the handling of gasoline, but who are exposed to its hazard merely because they happen to be in the vicinity. A great many fires occurring during filling operations may be attributed to carelessness and nothing else.

Fire Record of Automobiles.

In addition to usual reports in the N.F.P.A. Department of Fire Record files, there have been included in this fire record, statistics obtained from daily reports of salvage corps in several of the larger cities and from the annual reports of fire marshals of several states. These data have been supplemented by newspaper accounts and reports furnished by N.F.P.A. members, most of which refer to loss of life or injuries.

This record does not include those fires from the N.F.P.A. fire record files, where automobiles were burned while in garages, nor does it include fires which involved automobile tank trucks. The former are included in the Garage Fire Record (QUARTERLIES Vol. 22, No. 4, and Vol. 23, No. 1) and the latter form a special hazard which warrants separate classification. A fire record of tank trucks was published in the QUARTERLY, Vol. 18, No. 3.

The relative frequency of city automobile fires can be determined by the following table, which shows the number of fires occurring in motor vehicles in five different cities over a period of eight years.

Number of Automobile Fires.

Year	New York City	Boston	Baltimore	San Francisco	St. Louis
1920.....	1,018	236	102	126	...
1921.....	1,397	233	325	181	266
1922.....	1,452	281	365	202	388
1923.....	1,576	364	501	278	556
1924.....	2,018	444	548	322	536
1925.....	2,078	409	663	386	591
1926.....	2,417	535	764	446	637
1927.....	2,725	608	689	511	723
Total.....	14,681	3110	3957	2452	3697

These figures show clearly the importance of the problem from the fire department's viewpoint and are indicative of the effort which must be expended by the fire departments of the larger cities in extinguishing these fires, even though the aggregate losses are relatively small.

The increase in the number of fires in the period covered by the table is notable. Registration figures for the individual cities are not readily available, but a comparison of the increase in the number of fires from 1920 to 1927

P. & A. Photo.

Automobile fires are responsible for approximately 10% of all the fire calls in our large cities. This one occurred as the result of a collision between a ten-ton truck and a sedan.

with the increase in registration for the corresponding State for the same period gave the following results:

Comparison of Automobile Fires and Registration, 1920 to 1927.

City	Increase in Automobile Fires	State	Increase in Registration
New York	269%	New York	287%
Boston	247%	Massachusetts	253%
Baltimore	675%	Maryland	263%
San Francisco	405%	California	290%
St. Louis	272%	Missouri	229%

These percentages indicate that in two instances automobile fires are apparently increasing in direct proportion to the total registration of the State. In the other three cities the rate of increase of automobile fires exceeds the rate of increase in registration. This in spite of improved and safer design and construction.

The next table shows the causes of automobile fires. This table is a composite analysis based upon the automobile fire experience of five widely separated cities and one Canadian province. These data agree with surprising closeness, and based as they are on more than 5000 fires may well be taken as indicative of automobile fire experience. There has been no attempt to separate pleasure cars and trucks, analysis having shown the hazards and causes of fires of both classes to be about the same.

This table of fire causes indicates that the major cause of automobile fires is short circuit or defective wiring. Just as "defective wiring" is listed as a cause for a great many building fires when other factors are actually responsible, so may it also be possible that this cause has been unduly charged in this case. Nevertheless, carelessness in the protection of automobile wiring from chafing or from saturation by oil and gasoline undoubtedly leads to breakdown of insulation and a large number of fires.

Causes of Automobile Fires.

N.F.P.A. Department of Fire Record.

Special Hazard Causes.

Electrical Causes		2117
Short circuit or defective wiring	2108	
Defective battery connection	7	
Other electrical causes	2	
Fires Around Motor and Exhaust System		1126
Backfire	918	
Overheated motor	79	
Overheated exhaust pipe	55	
Grease or oil on exhaust pipe	20	
Waste or rags left on motor	18	
Waste or rags left on exhaust pipe	16	
Cleaning motor with gasoline	11	
Defective muffler	4	
Other motor or exhaust system causes	5	
Fires During Fueling Operations		185
Gasoline spilled on hot exhaust pipe	141	
Gasoline vapor ignited	21	
Static electricity	16	
Gasoline spilled on hot motor	4	
Other filling operation causes	3	
Fires Assigned to Gasoline Piping and Intake System		143
Leaking gasoline tank or piping	108	
Leaking carburetor	16	
Backfire in carburetor	12	
Looking for leak with match	4	
Other gasoline piping causes	3	
Other Special Hazard Causes		419
Collision or car upset	214	
Carelessness with gasoline	100	
Overheated brakes	78	
Alcohol in radiator ignited	10	
Thawing radiator with open flame	5	
Thawing carburetor with open flame	3	
Miscellaneous	9	
Total Special Hazard Causes		3990
Common Causes.		
Smoking—matches	271	
Lantern used as signal light	20	
Rubbish and oily waste	19	
Incendiary	10	
Malicious mischief	6	
Miscellaneous known causes	42	
Total Common Hazard Causes		368
Unknown Cause		903
Total		5261

If a car takes fire while traveling along the highway or while standing in a garage or on the street the chances are that the cause is short circuit in the wiring. When short circuiting occurs, the storage battery discharges at a high rate, an arc is usually formed at the point of the short circuit and considerable heat is generated. The insulation ignites and the flames spread to any flammable material near by. A "short" in the self-starter is particularly serious, because a heavy current flows to the starter motor and the temperature, therefore, would rise rapidly and to a high point.

Short circuits are caused by wires coming in contact with each other or with some metal part of the car, usually as a result of the wearing away of the insulation by friction. Whenever there is an odor of burning insulation about a car an immediate investigation should be made to determine its source—not only on account of the possibility of fire, but because of the damaging effect of a short circuit on the storage battery. A short circuit is also indicated when the ammeter needle swings to the extreme limit on the "discharge" side of the scale and remains there.

Loose connections may occasionally cause fires when the motor is running by creating sparks or arcs and igniting gasoline or fumes under the hood. It would seem that air circulating would obviate this, but fumes sometimes pocket in places where air does not circulate freely.

The second major cause of automobile fires is backfire, which has been grouped with other fires occurring in the vicinity of the motor and exhaust systems. For the most part these occur in the vicinity of the carburetor, although muffler explosions are usually listed as "backfire." Backfire is due to the improper adjustment of the carburetor or sticky or leaky intake valves. In either case a thin or lean mixture is admitted to the cylinders which will burn so slowly that the intake valve may admit a second charge before the

International.

When backfire from the motor set fire to this New York taxicab, firemen were summoned. Note use of 2½-inch water line to extinguish blaze around gasoline tank in cowl. (Compare this with illustration page 357.)

first is completely burned. The new charge is ignited by the flame of the first and blown back through the manifold and carburetor.

Other causes of fires around the motor and exhaust systems listed in the table are of obvious origin and may be considered entirely preventable in that they are, with the exception of four fires, due to defective muffler, the result of careless operation and maintenance.

One hundred and eighty-five fires are definitely known to have occurred during the operation of filling the gasoline tank. To these may probably be added a very considerable number of those attributed to carelessness with gasoline and smoking, for definite details were not available for a great many fires. The number of fires specifically listed as due to static electricity may similarly be incomplete, although modern filling station design and operation have done much to reduce the number of fires from this cause.

The static hazard may be eliminated or reduced by providing ground connections for dissipating the electric charge as it is generated, thus preventing the existence of a difference in potential between the nozzle and the ground. A good contact should be made between the nozzle and the tank while filling.

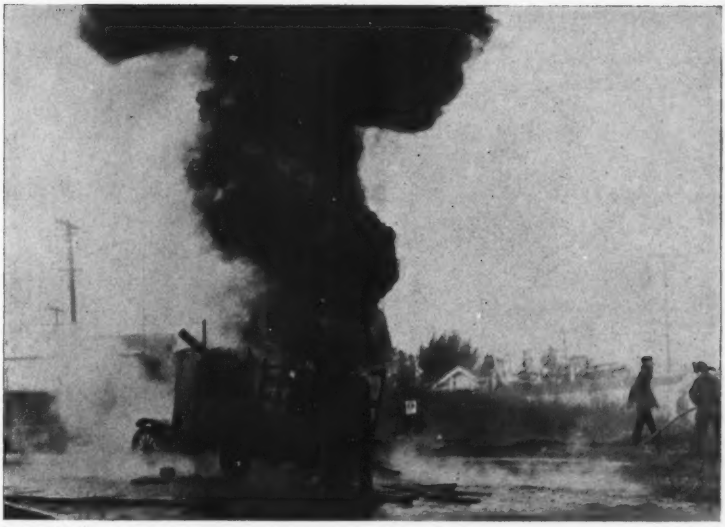
Leaks of one sort or another in the gasoline pipe line account for a considerable number of fires. Gasoline fumes may be present, with or without liquid gasoline, as a result of small leaks, and care should be taken that all leaks are immediately repaired. Particularly hazardous are carburetor leaks, which may ignite when the motor is started.

The other special hazard and common hazard causes need no comment. Their reasons for existence are plain, and the remedy for them is adequate maintenance and careful operation. Collisions and upsets are the result of thoughtless and reckless driving, often due to a state of complete or partial intoxication of the driver and occupants. Overheated brakes are largely due to improper adjustment or driving with brakes on. Smoking and careless disposal of matches is a problem in the fire hazard of automobiles even as it is in every other type of occupancy—a major cause and preventable, but difficult of elimination.

The following analyses of losses reported for the cities of Boston, Mass., for the year 1927, and St. Louis, Mo., for the eighteen months ended July, 1930, show how small a proportion of automobile fires entail a loss of any considerable amount.

Analysis of Losses—Automobiles.
St. Louis, Mo., October 1928-July 1930.

	Pleasure Cars		Trucks		Total	
	No.	%	No.	%	No.	%
No loss.....	362	36.2	110	38.7	472	36.8
Small loss.....	610	61.1	164	57.8	774	60.2
Considerable loss.	27	2.7	10	3.5	37	2.9
	999	100.0	284	100.0	1283	100.0



International.

Flames fed by gasoline from the tank under the seat quickly destroyed this truck and its load. In the case of truck fires the loss to the load may often be greater than that of the truck itself.

Analysis of Losses—Automobiles.
Boston, Mass., 1927.

Size of Fire	No. Fires	Loss
No loss	413	...
Under $5	13	$60
$7 to $10	17	164
$12 to $20	18	305
$25	14	350
$26 to $50	22	998
$50	18	900
$55 to $100	25	2931
$110 to $150	14	1800
$150 to $200	15	2750
$200 to $300	18	3995
$300 to $500	7	2911
$500 to $1000	9	6084
$1000 to $2000	5	8499
	608	$31,747

An analysis of the above table indicates that 442 fires, or 72.7% of the total number of fires, involved an individual loss of $10 or less. The aggregate loss occasioned by these fires was $224 or 0.7% of the total loss. The 68 fires involving a loss of more than $100 represented 11.3% of the total number of fires, and occasioned a loss of $26,039, or 82% of the total.

International.

A carelessly flipped cigarette stub which landed in a cotton laden truck was responsible for this fire.

Automobile Fires by Type of Cars, Boston, Mass., 1927.
All Fires.

Type of Car	No. Fires	%	Amount of Loss	%	Average Loss per Fire
Pleasure car	381	63	$16,864	53	$44
Trucks	187	31	11,410	36	61
Taxi	28	5	403	1	14
Bus	8	1	3,070	10	384
Tractor	1	0	.....	0	...
Hearse	1	0	.....	0	...
Motorcycle	2	0	.... .	0	...
	608	100	$31,747	100	$52

Fires With a Loss of Over $100.

Type of Car	No. Fires	%	Loss	%
Pleasure car	45	66	$13,108	51
Truck	19	28	9,693	36
Bus	3	4	3,070	11
Taxi	1	2	168	2
Totals	68	100	$26,039	100

From these tables it is indicative that while the largest total loss is on pleasure cars the loss per fire is greater for trucks. High value motor vehicles like busses have a very high individual loss. A consideration of the relatively few large fires in automobiles (the 68 with a loss of $100 or over) shows the offenders in this group to be pleasure cars.

Loss of Life in Automobile Fires.

The table which follows summarizes the loss of life in automobile fires as compiled by the N.F.P.A. Department of Fire Record. The fires included in this record have, for the most part, occurred during the past three or four years and represent but a small number of such fires, which, unfortunately, are occurring daily throughout the country. This table, as in previous fire records, indicates the cause of loss of life or injury rather than the cause of the fire.

Causes of Loss of Life and Injuries in Automobile Fires.

Fatalities classified according to the immediate cause of the loss of life rather than according to the cause of the fire.

	Pleasure Car or Truck			Motor Bus	
	No. Fires	Deaths	Injuries	Deaths	Injuries
Pinned in car after collision and burned.....	58	108	36	8	6
Trapped in burning bus or car.....	7	3	0	4	56
Clothing ignited while filling tank.....	7	6	2	0	0
Clothing ignited while using lighted match, cigarette or lantern in vicinity of tank...	9	8	4	0	0
Spectator burned from automobile fire.....	2	2	27	0	0
Miscellaneous known causes*.....	8	5	11	7	0
Unknown cause.....	3	3	0	0	0
Total	94	135	80	19	62

***Miscellaneous Known Causes.**

Clothing ignited while looking for gasoline leak.

Phosphorus in car ignited by heat of motor set fire to clothing.

Playing with matches in automobile—clothing ignited.

Burning tree fell on bus, trapping occupants.

Overcome by carbon-monoxide gas. Car caught fire from heater and occupants burned to death.

Fireworks on truck ignited by backfire. Resultant explosion killed two.

Clothing ignited by short circuit while repairing bus motor.

Draining gasoline from tank of car at filling station. Pit filled with fumes which ignited from air compressor.

Typical Loss of Life Fires.

APRIL 12, 1925, BROCKTON, MASS. While filling the tank of his car a man spilled some of the gasoline on his clothing. Someone near by lighted a match, igniting his clothing and fatal burns resulted.

JUNE 2, 1925, MCKEES ROCKS, PA. The backfire of a truck ignited fireworks with which it was loaded, causing a terrific explosion. The two men on the truck were killed.

JULY 6, 1925, SALEM, MASS. A woman standing behind a truck while the gasoline tank was being filled was fatally burned when an explosion occurred. Flame shot from the muffler and enveloped the woman's clothing.

OCT. 11, 1925, QUINCY, MASS. The tank of a car was being filled when some of the gasoline fell on to the hot exhaust pipe and ignited. The driver of the car, who was filling the tank, was so severely burned that he died.

AUG. 1, 1926, NEW YORK, N. Y. A man and his wife were burned to death when

International.

Returning home at 2 A.M., the driver of this Ford ran into an unlighted coupe. Both gasoline tanks burst into flames and the Ford driver, pinned in the wreckage, was burned to death before help arrived.

their car struck a lamp post and caught fire when gasoline, escaping from the wrecked tank, ignited.

Nov. 1, 1926, DAYTON, OHIO. A woman and six children were burned to death when a truck in which they were riding collided head on with an interurban car and burst into flames.

Nov. 15, 1926, SAUGATUCK, MICH. Fire occurred when an automobile skidded and overturned. The driver managed to crawl from under the car, but his son was trapped and burned to death.

JAN. 24, 1927, GREENFIELD, MASS. Two people were killed when they were trapped in an automobile after it overturned and caught fire.

FEB. 1, 1927, DEDHAM, MASS. Men were trying to trace a leak in the gas line of a truck with a match when an explosion occurred. One man died from burns received and two others were severely burned.

JUNE 5, 1927, WATERVILLE, MAINE. Two automobiles collided and caught fire. Two of the occupants were wedged between the cars and burned to death.

JULY 15, 1927, MOLINE, ILL. An automobile plunged down a slope and caught fire. Two men were burned to death.

AUG. 17, 1927, CHICAGO, ILL. An automobile struck an electric light pole and caught fire. The driver was burned to death. Three other occupants of the car were injured but escaped.

DEC. 10, 1927, BROOKFIELD, MASS. An automobile collided with the rear of a truck and caught fire. The truck driver attempted to release the man who was trapped inside the burning car, but was unable to do so due to the intensity of the flames.

MARCH 12, 1930, IPSWICH, MASS. A truck crashed into a tree and caught fire. The driver was burned to death and his helper was severely burned.

MARCH 30, 1928, BERLIN, CONN. A truck driver was burned to death in the wreckage of his machine after it had crashed into an abutment on the state highway.

APRIL 2, 1930, WHITE PLAINS, N. Y. One man was burned to death and two others were severely burned when a closed automobile in which they were riding broke a temporary gas main at the side of the road. The escaping gas ignited and they were trapped by the flames.

JULY 27, 1928, ROCKVILLE, CONN. An auto truck carrying a load of children skidded and overturned, pinning three underneath. Gasoline caught fire and the three trapped children died before the truck could be righted.

AUG. 4, 1928, ELMIRA, N. Y. The tire of an automobile blew out, throwing the machine off the highway, where it overturned. Escaping gasoline ignited and the four occupants were burned, two fatally.

AUG. 5, 1928, CHICAGO, ILL. An automobile drove into a train at a grade crossing at which the gates had not been lowered. The machine was hurled from the track. Gasoline ignited and the unconscious occupants burned to death before they could be given aid.

AUG, 27, 1928, ATLANTIC CITY, N. J. A truck and bus were in collision. The truck driver was imprisoned by the load of vegetables in the truck and was burned to death when his vehicle caught fire.

SEPT. 3, 1928, CAMP HILL, PA. A woman was fatally burned when she lighted a match to see if the gasoline tank of her car was empty.

OCT. 1, 1928, WATERTOWN, S. D. The tank of a motorcycle overflowed while being filled. The gasoline was ignited by the hot exhaust pipe of the machine and the rider was burned to death.

OCT. 6, 1928, JOLIET, ILL. A woman driver lost control of her car while attempting to pass another machine. The car overturned and ignited. She was seriously burned and her invalid mother, riding with her, was burned to death. Another woman occupant escaped without serious injury.

NOV. 1, 1928, MOUNTAIN LAKES, N. J. An automobile in which two women were riding was overturned, and fire followed in which both women lost their lives.

DEC. 1, 1928, PETTUS, ARK. A man was found dead in the cab of a burning truck. Fire was believed to have been due to defective wiring.

DEC. 2, 1928, FORT SMITH, ARK. A woman died in a hospital of burns which she received when a car in which she was riding overturned on the highway.

APRIL 4, 1929, REVERE, MASS. A driver of a truck lost control of his machine in attempting to avoid a collision. The truck struck a pole and overturned. Fire followed the crash, and a passenger on the truck was pinned underneath and burned to death.

APRIL 20, 1929, TORONTO, ONT. A man was burned to death when his car, going at a high speed, skidded into a street car and burst into flames.

MAY 30, 1929, ELIZABETHTOWN, PA. While under the influence of liquor the driver of an automobile struck the car ahead. His machine then went off the road and into a stream, where it burst into flames. The driver was fatally burned.

MAY 30, 1929, YPSILANTI, MICH. A car carrying four persons was going at a high rate of speed when it struck guard cables at the edge of the highway and rolled down a 25-foot embankment. Fire followed in which the four occupants lost their lives.

JULY 12, 1929, MEMPHIS, TENN. A man and his wife were fatally burned when their car struck a parked car at the side of the road and caught fire.

JULY 24, 1929, BARRE, MASS. An automobile engine was left running while the gasoline tank was being filled. The engine backfired and ignited the gasoline. The driver of the car was trapped inside and was so severely burned that he later died.

JULY 27, 1929, BRANFORD, CONN. Two automobiles crashed head on and burst into flames. Four persons were killed and three were injured. Two of the victims were burned to death in the flaming wreckage, and two of the five persons who were pulled to safety died in the hospital of the burns they received.

AUG. 13, 1929, TYNGSBORO, MASS. A truck got out of control while on a long down grade and crashed into a tree, overturned and caught fire. The driver was burned to death.

NOV. 2, 1929, HAYTI, MO. Three members of one family were burned to death when they were trapped in their overturned automobile after a crash.

Nov. 14, 1929, WESTERLY, R. I. A truck struck two others and caught fire. The driver was trapped in the cab and burned to death.

Nov. 17, 1929, WICHITA, KANS. A light automobile ran into a parked truck. A steel rod extending from the rear of the truck punctured the gasoline tank located under the hood of the car, allowing gasoline to flow on the hot motor and ignite. Three persons were burned to death and one was injured.

APRIL 12, 1930, STERLING, KANS. An automobile was crowded off the road into a ditch by another car. It overturned, took fire and three of its six occupants were burned to death.

Nov. 8, 1930, ANDOVER, MASS. A woman was suffocated and fatally burned when a small sedan in which she was riding collided with a truck ahead. A steel rod protruding from the rear of the truck pierced the gasoline tank which was in the forward part of the sedan, allowing gasoline to escape on to the hot motor, where it ignited. The car was quickly involved by fire. Four men occupants were somewhat burned before they escaped, leaving the woman to her fate. The entire party had been drinking.

Motor Bus Fires.

The tremendous increase in bus transportation during the past few years in all sections of the United States and Canada carries with it the possibility of a major catastrophe from a loss of life or injury standpoint. An accident to a pleasure car or even a motor truck may involve the driver and possibly three or four others, but an accident to a motor bus may endanger from 30 to 50 persons. This possibility of injury and the consequent liability are recognized by the bus transportation officials, and they make sure as far as possible that bus drivers are competent and busses are maintained in good condition. The regulations of many states as well as operating companies already have in mind the safety of the passengers as their first concern, and demand is being

International.

The combustible handle of an umbrella resting against a heater ignited and caused the fire which destroyed this motor bus near Ridgewood, N. J. Note single exit for passengers at front of bus.

made of those who have been backward to provide adequate safety regulations.

The fire record files of the N.F.P.A. contain records of 20 fires which have occurred since 1924 in busses. These obviously represent but a small portion of such fires that have occurred during this period, but at the same time they are sufficiently varied to indicate the hazards of bus operation from a fire standpoint and throw considerable light on the possibilities for serious loss of life and injury.

Typical Motor Bus Fires.

Nov. 5, 1924, New York, N. Y. A bus caught fire at a filling station while the gasoline tank, located under the hood, was being filled. It is thought that when the hose was removed from the tank, gasoline dripped on to the hot motor or exhaust pipe and ignited. A flash followed and a sheet of flame flashed into the crowded bus.

There was but one small door and a stampede resulted. Firemen from a near-by station responded, but by the time they had smashed windows and torn away the woodwork at the rear of the bus, through which they lifted the passengers to safety, the clothing of many of the passengers was ablaze. Three women were critically burned and eleven other persons were either burned or painfully cut by glass. The bus was considerably damaged. (H-21555.)

Dec. 16, 1925, Shrewsbury, Mass. Ten passengers hastily left a New York to Boston bus when fire burst out from an unknown cause under the second seat and spread rapidly to other parts of the large bus. The bus was damaged to the extent of $7500. (H-22857.)

March 14, 1926, Longmeadow, Mass. Fourteen passengers were taken from a burning bus after a head-on collision with a motor truck. The force of the impact was so great that the truck climbed the front of the bus for a distance of about eight feet. The fuel line of the truck was broken, allowing gasoline to flow on to the hot motor of the bus, where it ignited. Despite the efforts of the fire department the bus was destroyed within a few minutes of the accident. All of the passengers escaped, but were more or less burned and otherwise injured. Three suffered severe burns. (H-23168.)

July 5, 1926, Watertown, Mass. A Boston to New York bus caught fire while passing through Watertown. While the bus was being washed in the garage prior to starting the run a rubber blanket had been placed over the motor to keep it dry. This blanket was not removed, with the result that the heat from the motor set fire to it and the machine. The passengers escaped without difficulty and the fire was extinguished with minimum damage. (H-23551.)

Sept. 9, 1926, Norwood, Ohio. This accident occurred about two-thirds of the way down a long hill leading to the city. On this hill are concrete

International.

The driver of this Los Angeles-San Francisco auto stage states that he could easily have extinguished the fire at the start with a small extinguisher. The bus was not so equipped and the photograph shows all that was left.

street car loading platforms protected by heavy concrete blocks. It is not known whether the bus skidded due to a light rain or whether the accident was due to the carelessness of the driver in making a turn, but the bus struck one of the concrete blocks, rupturing the gasoline tank mounted under the body.

Flames enveloped the bus when the leaking gasoline ignited. There were two exits (front and rear) on the bus. Those using the front exit were slightly burned, but those leaving by the rear escaped without harm. Fortunately there were but few passengers in the bus, which was badly damaged. Blazing gasoline flowed for more than 1500 feet down the hill before it was finally extinguished by the fire department. (H-23860.)

DEC. 22, 1927, MILFORD, CONN. An umbrella of pyroxylin material carried by a passenger and which had been in contact with a heater was the cause of a fire which destroyed a New York to Boston bus. The umbrella had been on the heater from the start of the trip from New York and suddenly burst into flames. The twenty-five passengers escaped safely. Chemical extinguishers carried by the bus were used without success, and by the time the fire department reached the scene the fire was beyond control. The loss was estimated at $15,000. (H-25367.)

FEB. 26, 1928, WATERTOWN, MASS. A sight-seeing bus carrying thirty passengers to Concord and Lexington caught fire when upholstery on one of the seats ignited from a heater. Passengers discovered the fire and notified the operator, who drove up to a fire alarm box and sounded an alarm. The passengers left the machine until firemen arrived and extinguished the fire. They then re-entered the bus and continued on their journy. The damage was slight. (H-25659.)

APRIL 1, 1928, YORK, ME. Heavy traffic along the main highway was delayed for more than an hour when a motor bus bound from Boston to Portland caught fire. The fire is thought to have been due to an overheated exhaust. The bus was completely destroyed with a loss of $8000. The occupants, comprising two passengers and the driver, were unhurt. The tie-up of traffic extended for more than two miles. (H-25824.)

AUG. 20, 1928, RED WING, MINN. Four men were burned to a crisp and two others were so badly burned that they died later, when a large motor coach carrying passengers between Chicago and the Twin Cities collided with a truck. According to survivors of the crash the accident was due to slippery pavement and an attempt on the part of the driver to make up for lost time. Following the collision the bus careened to the side of the road, tipped over and burst into flames. Four men were trapped in their seats and burned beyond recognition. Six others escaped through broken windows or were rescued by fellow passengers. All were burned and two so severely that they later died. One lone passenger escaped without injury. The bus was completely destroyed. (H-26396.)

AUG. 24, 1928, NEWPORT, PA. Thirty-two passengers escaped with minor injuries when a Chicago to New York bus caught fire following an accident. The bus lost a tire, snapped off twelve guard cable ports at the edge of the road, and rolled over a twenty-foot embankment. Fire soon followed when escaping gasoline was ignited by the hot engine. All of the passengers escaped and most of the baggage was saved before the bus was destroyed by fire. (H-26613.)

DEC. 20, 1928, PROVIDENCE, R. I. A motor bus caught fire while on the New London road. This bus had twin motors which were underslung on the right and left sides of the bus and located amidship under side seats. As the motors on both sides are alike, the exhaust manifold on the left-hand side motor did not permit a proper clearance between the manifold and the woodwork. The heat from this manifold ignited the floor boards.

The driver was unable to extinguish the fire with a carbon tetrachloride extinguisher carried on the bus. Fortunately a load of sand was passing at the time and this was used to extinguish the fire. The loss, including damage to engine, wiring, etc., was $685.00. (H-27547.)

FEB. 3, 1929, REDDING, CALIF. A "sleeper" bus en route between San Francisco, Calif., and Portland, Ore., crashed and overturned on the highway near Redding. Fire resulted in which the driver was fatally burned. Passengers who were asleep at the time were awakened by the crash. They smashed the rear windows and escaped without serious injury. (H-27177.)

FEB. 25, 1929, HOPE VALLEY, R. I. One person, a blind man, was burned to death and sixteen others were burned (three of them seriously) when a Boston to New York bus caught fire. The fire is thought to have been due to

the ignition of a newspaper in contact with the heater at the front of the car.

At the cry of "fire" there was a rush for the exit. Some of the passengers broke windows to escape, others used a rear door. A blind man riding in the front part of the bus near where the fire started was burned to death. Among the passengers severely burned was a twenty-three year old girl whose glasses, the frames of which were of a flammable material, ignited and burned her eyes. The bus was completely destroyed. (H-29770.)

JULY 3, 1929, SARATOGA SPRINGS, N. Y. A Montreal-New York bus caught fire halfway between Saratoga Springs and Glens Falls. The cause is not definitely known. The fire occurred at the rear of the bus. Twelve passengers on the bus escaped without injury but lost their baggage. The bus was considerably damaged. (H-28444.)

SEPT. 16, 1929, PLYMOUTH, WIS. A Sheboygan-Fond du Lac motor bus overturned and caught fire following a collision. One passenger was burned to death and two others were injured in the accident. (H-28117.)

NOV. 6, 1929, SOMERVILLE, MASS. Fire started in a brake and spread to the floor boards of the bus. A dozen passengers left the bus while the fire was extinguished by first aid fire equipment used by the driver and by firemen. Loss $25. (H-29030.)

DEC. 5, 1929, HINSDALE, N. Y. Seventeen passengers, most of them in their stocking feet, were forced out into the snow when a New York to Buffalo bus caught fire at midnight, due to a short circuit. The fire was extinguished by first aid fire appliances carried on the bus. None of the passengers were injured, although they suffered some discomfort due to the weather. (H-28548.)

Prevention and Extinguishment of Automobile Fires.

Careful maintenance of motor cars and trucks will go a long way toward preventing many of the fires to which such vehicles are subject. Owners of fleets of trucks and busses in particular should be encouraged to keep their motor compartments clean and to periodically inspect the wiring that it may be kept in proper condition.

This fire record reaffirms the necessity of close attention to business when filling gasoline tanks, and the need for care in handling gasoline around filling stations and garages. Smoking should be absolutely prohibited.

All types of first aid extinguishers have been used on automobile fires with success. For use on pleasure cars and ordinary motor trucks the carbon tetrachloride one-quart size is the most convenient to carry and furnishes a reasonable degree of protection. For busses and large trucks (particularly trucks with enclosed bodies and carrying unusually valuable contents) carbon dioxide systems are being employed. Such systems are piped to the motor compartment and to the body.

The following record is typical of the method of extinguishing automobile fires by city fire departments. For the most part these fires are handled by extinguishers or chemical lines; only in occasional instances are hose streams employed. The extinguishers used are of all types—soda-acid, carbon tetrachloride, foam and carbon dioxide devices all proving effective.

How Automobile Fires Were Extinguished by the Boston Fire Department, 1927.

	No. Fires
Put out by extinguishers	301
Chemical stream, etc.	85
Hose stream	27
Water pails	30
Sand	39
Miscellaneous	23
No data	103
Total fires	608

International.

Usually streams from hand extinguishers suffice to handle fires in and around automobile motors. Chicago firemen extinguishing fire due to short circuit in wiring in a practically new sedan.

Fires in Which There Was a Loss of Life.

Since the publication of the last QUARTERLY the Department of Fire Record of the N.F.P.A. has received from various sources a total of 157 reports of fires in which loss of life has been a factor. For the most part the fires recorded have occurred since October 1, 1930. While the number of fires reported to the N.F.P.A. is but a small fraction of the total number that have occurred during this period, the volume of data is sufficient to indicate the predominating causes of loss of life. These reports indicate a total of 374 lives sacrificed by fire during the period, 122 of which occurred in three mine disasters.

The three mine fires involving large loss of life were those occurring on October 27, 1930, at McAlester, Okla., involving loss of 30 lives; on November 5, 1930, at Millfield, Ohio, where 79, including the executive staff of the company, were killed; and on November 27, 1930, at Lutie, Okla., when 13 were killed and 5 injured. In each of these disasters the cause of the fire appears to have been an explosion of accumulated gas or vapor, and death appears to have been due to the effects of the explosion rather than to suffocation or being trapped in the burning mine.

Loss of Life Fires, October-December, 1930.*

Class of Fire	No. Fires	Lives Lost				
		Men	Women	Children	No Data	Total
Airplane accidents	10	16	5	0	0	21
Automobile accidents	17	19	3	2	4	28
Apartment hotels, tenements, etc.	7	10	3	0	0	13
Dwellings—Urban	37	9	11	30	0	50
Dwellings—Rural	34	19	7	33	0	59
Garages and filling stations	4	6	0	0	0	6
Industrial occupancies	5	7	1	0	0	8
Institutions—schools, etc.	3	1	0	0	4	5
Mercantile occupancies	5	5	0	1	0	6
Mining property	6	133	0	0	0	133
Oil fields	2	3	0	0	0	3
Other buildings	11	13	1	3	0	17
Other than buildings	6	2	0	5	0	7
Railroad accidents	2	2	0	0	0	2
Response to alarms	3	3	0	0	0	3
Ships	5	12	1	0	0	13
Total	157	260	32	74	8	374

*This table is made up from those reports received by the Department of Fire Record between October 1 and December 30, 1930. A few of the fires included herein occurred prior to October 1, but were not reported until subsequent to that date.

Causes of Loss of Life, October-December, 1930.

Fatalities classified according to the immediate cause of the loss of life rather than according to the cause of the fire.

Cause	Men	Women	Children	No Data	Total
Airplane accidents	16	5	0	0	21
Automobile accidents	19	3	2	4	28
Children and matches	0	0	10	0	10
Cleaning with gasoline	0	2	1	0	3
Clothing ignited from stove	0	3	4	0	7
Clothing ignited from Jack o' Lantern	0	0	1	0	1
Clothing ignited from bonfire	0	0	2	0	2
Clothing ignited from fireplace	0	0	1	0	1
Clothing ignited from candle	0	1	0	0	1
Electrocuted while fighting fire	1	0	0	0	1
Escaping from fire—cut by glass	1	0	0	0	1
Escaping from fire—died by jumping	1	0	0	0	1
Explosion—boiler	2	0	0	0	2
Explosion—fireworks factory	2	0	0	0	2
Explosion—gas appliance	2	0	1	0	3
Explosion—gasoline stove	1	0	1	0	2
Explosion—illicit still	4	0	0	0	4
Explosion—mine	128	0	0	0	128
Explosion—oil field	2	0	0	0	2
Explosion—paint factory	3	0	0	0	3
Explosion—printing plant	1	1	0	0	2
Fell on stove	1	0	0	0	1
Fire fighting	6	0	0	0	6
Gasoline used to start fire	2	1	6	0	9
Ignition of flammable liquids or vapors	16	3	0	0	19
Kerosene used to start fire	2	1	7	0	10
Oil lamp or stove	2	0	1	0	3
Overcome by smoke or suffocation	4	3	8	0	15
Overexertion or excitement due to fire	4	0	0	0	4
Re-entering burning building	3	1	1	0	5
Railway accident	2	0	0	0	2
Responding to alarm	2	0	0	0	2
Smoking in bed	2	0	0	0	2
Trapped in burning building	25	8	28	4	65
Trapped in burning mine	5	0	0	0	5
Set clothing on fire (intoxicated)	1	0	0	0	1
Total	260	32	74	8	374

While for tabulation purposes only those loss of life fires occurring in the United States and Canada have been used, mention should be made at this time of three European disasters, which because of their magnitude may well be regarded as world disasters. These disasters are the loss of the British Dirigible R-101 at Beauvais, France, and the two mine disasters in Germany involving a total loss of more than 400 lives. The following information regarding these loss of life fires has been taken from press reports.

The accident to the British Dirigible R-101 occurred shortly after midnight on October 5, 1930. The airship, the largest dirigible in the world, was on its maiden flight when it crashed into a hillside near Beauvais, France, during a storm and immediately burst into flames. The cause of the disaster has not been definitely determined. Of the 55 persons aboard, all but seven lost their lives. Nothing remained of the great airship but a twisted mass of steel.

The first of the German mine disasters took place on October 21, 1930, at the Anna coal mine at Alsdorf, when a terrific explosion some 1200 feet below the surface snuffed out the lives of 255 mine workers. Apparently there were three explosions. The first, a gas blast, caused dynamite stored in one of the shafts to explode. This in turn blew up gasoline tanks, in a building on the surface, demolishing the building and causing the collapse of the adjoining administration building. Most of the victims were killed by the explosion or asphyxiated by the resultant gas and smoke.

Four days after this disaster, on October 25, 1930, another mine explosion occurred in the coal mine of the Maybach Colliery at Quierschiete in the heart of the Saar Valley coal region, about 100 miles from Alsdorf. This explosion is thought to have been due to a coal damp explosion, which touched off coal dust stirred up by a blast in another part of the mine. Smoke and gas hampered the rescue of the imprisoned miners, and 107 of them perished. Of the bodies recovered but 49 could be positively identified. This mine was under French control by the terms of the Versailles treaty. It was known to be subject to coal damp, but elaborate precautions had been taken and it was regarded as a model mine.

Typical Loss of Life Fires.

Clothing Ignited by Jack o' Lantern.

FALL RIVER, MASS., OCT. 31, 1930. A 12-year-old girl was fatally burned when the paper costume which she was wearing at a Hallowe'en party was ignited by the flame of a jack o' lantern carried by another child. A woman was critically burned in attempting to save the child's life. (L-922.)

Cleaning with Gasoline.

NEW YORK, N. Y., DEC. 20, 1930. A woman was burned to death in the kitchen of her home when fumes from gasoline, which she was using to clean a dress, ignited from the open flame of a gas range. She was fatally burned before assistance could reach her. (L-904.)

Explosion in Fireworks Factory.

DARIEN, CONN., DEC. 4, 1930. Two men were killed and two others seriously burned in a fire which destroyed a fireworks factory. An employee was loading an aerial bomb which in some way ignited. The man dropped the burning explosive and it fell into a container full of finished bombs, which were discharged. (H-30509.)

Explosion of Gasoline Appliance.

WHITEWATER, KANS., AUG. 10, 1930. A restaurant proprietor lost his life when a gasoline pressure cook stove exploded as he attempted to light it. The fire gained rapid headway due to the spraying of gasoline on the floor, and the man was so severely burned before he could escape that he died in a hospital within a few hours. (H-30319.)

Gas Explosion.

LEAD, S. D., OCT. 17, 1930. A man was fatally burned as the result of a gas explosion and fire which occurred in his room. Apparently the room was filled with gas due to a leak, and the blast occurred when he attempted to light a gas heating appliance. (L-921.)

NORTH TONAWANDA, N. Y., Nov. 29, 1930. The fire department had been called to repair a gas leak in the basement of a two-story frame dwelling adjacent to the fire station. The firemen opened all the windows to allow the gas to escape and were standing outside of the building when a terrific explosion occurred, entirely demolishing the building. One fireman was killed and ten other persons were seriously injured. The blast was due to the ignition of the gas by the furnace fire. (L-924.)

BATH, OHIO, DEC. 1, 1930. Five members of a school basket-ball team were badly burned, one fatally, in a gas explosion which occurred in the basement of the school while they were in the boiler room dressing for a game. It seems probable that gas used in the domestic science classroom leaked from the piping and ignited from the boiler or some other source. (H-30518.)

Gasoline Explosion on Boat.

MIAMI BEACH, FLA., DEC. 14, 1930. Two men and a woman lost their lives when a "see bottom" boat carrying 133 persons caught fire and sank following the ignition of accumulated gasoline fumes in the engine room from sparks from a generator. It was some time before the survivors were picked up, some suffering from burns and shock, and there was no other craft near at the time of the accident. (H-30508.)

Ignition of Escaping Gas.

BEATTYVILLE, KY., DEC. 6, 1930. A father and three children were burned to death when an early morning fire destroyed the one-story frame house in which he lived. His wife, who escaped with three other children, was critically burned. Gas escaping from an open jet is believed to have been ignited by a kerosene lamp. The house was enveloped in flames before any of the family awoke. (L-891.)

Starting Fires with Kerosene or Gasoline.

PARSONS, KANS., OCT. 18, 1930. Four persons lost their lives and five others were seriously burned when a farmer poured kerosene on the smoldering fire in his stove in order to revive it. The father escaped from the burning building, but lost his life when he returned in an attempt to save the three children who were trapped. (L-768.)

PITTSFIELD, MASS., OCT. 19, 1930. A thirteen-year-old boy was fatally burned when he poured gasoline, which he mistook for kerosene, into a stove. An explosion occurred as live coals ignited the gasoline. (L-766.)

EAST LIVERPOOL, OHIO, OCT. 22, 1930. Three children were burned to death and a fourth was injured in a flash fire which occurred when their mother poured kerosene on the fire in the stove. (L-763.)

Ignition of Flammable Liquids or Vapor.

HARTFORD, CONN., AUG. 19, 1930. A man was burned to death as the result of an explosion and fire which occurred in the basement of an office building at a gasoline filling station. A leak had developed in the underground pipe lines from the storage tanks to the filling pumps due to the settling of filled-in ground close to the basement wall of the building. The victim of the fire was using a broom to sweep up the gasoline which had filtered into the basement. It is believed that his broom broke an electric light bulb, which ignited the fumes. (H-30201.)

AMHERST, NOVA SCOTIA, OCT. 21, 1930. Three men employed in a machine shop were using a fuel oil torch to heat metal and forge a flange by hand. The man handling the torch shut off the oil supply and placed the torch on the ground, pointing toward the other two men, who were standing near by. The oil valve was either opened accidentally as the torch was put down or the workman opened it thinking he was closing the air valve. The atomized oil sprayed over one of the men and the hot metal. The oil immediately ignited, fatally burning one man and seriously burning the other. The third workman was uninjured. (H-30433.)

SALEM, MASS., DEC. 5, 1930. A young woman died of burns received when her clothing was ignited while working in a radio tube factory. Prior to the accident she had tipped over a small can of alcohol on her machine and the liquid spilled on the sleeve of her dress. She was ordered by the foreman to change her dress to allow the alcohol to evaporate before it was worn about the factory again. When she shut off the machine a spark from the switch ignited the alcohol-soaked sleeve. The girl ran about the room, causing the fire to spread and inflict severe burns over almost her entire body, which caused her death. (H-30520.)

PROVIDENCE, R. I., DEC. 11, 1930. Four garage employees were burned, three of them fatally, when an electric light bulb dropped into a pit in which they were working, broke and ignited gasoline on the floor of the pit. The flames spread rapidly, fed by oil and gasoline on the floor of the garage, and before they could reach the door, which was closed, three of them were so badly burned that they died in a hospital later.

FREDERICK, MD., DEC. 13, 1930. An automobile mechanic died of burns received when gasoline on his clothes caught fire as he was lighting a cigarette.

The man had spilled gasoline on his clothing while filling the tank of an automobile. (L-900.)

GREENVILLE, S. C., DEC. 25, 1930. A man was fatally burned at an airport office, where he was employed as a plane dispatcher, when he placed a bucket containing gasoline on a stove to heat. He thought that it was water. When the liquid started to boil he discovered his mistake and, in his hurry to remove it from the stove, he knocked the bucket over. The gasoline ignited and flames instantly enveloped the room. Two others were seriously burned trying to rescue the victim. (H-30512.)

Mine Explosions.

MCALESTER, OKLA., OCT. 27, 1930. Thirty miners were instantly killed in a coal mine explosion of unknown origin. There were 29 men in the shaft at the time of the explosion and not one escaped death. Another miner at the mouth of the mine shaft was also killed. The mine was located on the State Penitentiary farm. (H-30462.)

MILLFIELD, OHIO, NOV. 5, 1930. Seventy-nine men lost their lives in a mine gas explosion and fire, the origin of which was traced to an unused entry about a mile and a half from the main shaft. The ignition of the gas was due to a trolley wire that had been broken by a fall of slate, and in falling one end shorted against the rail or ground, producing an arc. (H-30460.)

LUTIE, OKLA., NOV. 29, 1930. Fifteen miners lost their lives due to a gas explosion in a mine. Thirteen of the victims were killed outright. The fact that the mine was heavily rock dusted probably made possible the escape of 40 other miners in the shaft. (H-30517.)

Oil Tanker Explosion.

JACKSONVILLE, FLA., AUG. 16, 1930. Five men were fatally burned when an explosion occurred in the engine room of a tanker. The fuel oil cargo which was being discharged was ignited by the blast. Four of the victims were visitors who were inspecting the engine room at the time. (H-30127.)

Suffocation by Smoke.

WINCHESTER, VA., NOV. 17, 1930. Three persons lost their lives by suffocation in an early morning fire which destroyed an apple packing plant adjoining the building in which they lived. The father had returned to save his wife and child, but all three were overcome before they reached the window and died shortly after being taken out of the building by firemen. (H-30514.)

BOSTON, MASS., OCT. 29, 1930. A woman rooming on the second floor of a three-story frame dwelling died of suffocation as a result of a fire which started in the basement. The fire occurred when a flammable fluid being used for cleaning the windows in the basement kitchen was ignited and smoke spread rapidly through the building. (L-917.)

National Fire Protection Association

INTERNATIONAL

Executive Office: 60 Batterymarch St., Boston, Mass.

The National Fire Protection Association was organized in 1895 to promote the science and improve the methods of fire protection and prevention, to obtain and circulate information on these subjects and to secure the coöperation of its members in establishing proper safeguards against loss of life and property by fire. Its membership includes over a hundred national and regional societies and associations and more than four thousand individuals, corporations, and organizations.

The QUARTERLY is one of a large number of publications issued by the Association and sent to the members as published. These include the monthly *News Letter,* standard regulations on fire prevention and fire protection, special reports and bulletins, the Year Book, and the Proceedings of the annual meetings.

Membership in the National Fire Protection Association is open to any Society, Corporation, Firm or Individual interested in the protection of life or property against loss by fire. All the valuable engineering and popular literature issued by the Association is sent, as issued, to every member. The Association is the clearing house for all the authoritative information on Fire Protection and Prevention, and members are privileged to submit to it their individual problems for solution. The Association is always glad to send samples of its publications to prospective members upon request.